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JOURNAL OF MAMMALOGY

VOL. 25 5 FEBRUARY 1944 NO. 1

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The Journal of Mammalogy

Subscription rates, $4.00 per year; single numbers $1.00 each. Sent free to all members of the American Society of Mammalogists not in arrears for dues.

Subscriptions, changes of addresses, requests for missing numbers, applications for advertising rates, etc., should be addressed to the corresponding secretary, Emmet T. Hooper, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

Manuscripts for publication, books and papers for notice and reviews, etc., should be sent to William B. Davis, Department of Fish and Game, College Station, Texas.

Entered as second-class matter, November 25, 1919, at the Postoffice, Baltimore, Md., under the act of March 3, 1879

Made in United States of America

JOURNAL OF MAMMALOGY

Published Quarterly by the American Society of Mammalogists

VOL. 25 FEBRUARY 15, 1944 No. 1

THE BIOLOGY OF THE LITTLE SHORT-TAILED SHREW, *CRYPTOTIS PARVA*

BY W. J. HAMILTON, JR.

The little short-tailed or least shrew (*Cryptotis parva*) is widely distributed east of the Great Plains, from southern Ontario to Florida and west to eastern Nebraska and Texas. While it is by no means uncommon in mammal collections, the number of specimens taken by the collector is usually small in proportion to other mammals. This apparent scarcity is not reflected in the success of more experienced collectors, such as the owls. Davis (1938) found a heavy concentration of *Cryptotis* remains in the dejecta of barn owls from Colorado County, Texas. No less than 171 of these shrews constituted 41 percent of the small surface mammals represented in the pellets. I have been told by several collectors that all efforts to collect these little shrews have proven futile in spite of the fact that owl pellets in the very region which they had trapped contained numerous skulls of *Cryptotis*.

In spite of the difficulty attendant on securing a series of this shrew, we know through a study of the food of owls that this scarcity is an apparent rather than a real one. *Cryptotis* is widespread and apparently not uncommon, but other than fragmentary notes, little has been contributed toward the life history of this diminutive insectivore. Accordingly it seems desirable to place on record certain data that add to our knowledge of the species.

HABITAT

In the illimitable marshes of the South Atlantic coastal region this shrew is not uncommon. On the marshes of Cape Charles, Virginia, *Cryptotis* are fairly numerous on the tidewater flats and offshore islands, particularly where the brackish streams rush in and out with the ebb and flow of the tide. Here, in the dense growth of *Distichlis spicata*, salt marsh grass, *Spartina alternifolia* and glasswort, *Salicornia europea*, numerous runways of the rice rat (*Oryzomys palustris*) crisscross through the marsh. At Chincoteague, Virginia, I trapped in such a marsh on September 7, 1940, and caught 7 *Oryzomys*, 8 *Microtus pennsylvanica* and 3 *Cryptotis*. The following day the traps held a number of *Oryzomys*, *Microtus* and another *Cryptotis*. On July 1, 1941, I took a live *Cryptotis* at the same place. These shrews were apparently occupying the runways of *Microtus* and

Oryzomys, travelling out into the black muddy tidewater reaches in search of the tiny invertebrates that swarm in such places, and retreating to the canopy of dead grasses about the clumps of the groundsel tree, *Baccharis halimifolia*, and the marsh elder, *Iva frutescens*, as the tide covered these feeding areas. At the base of one of these elders I found a tiny nest of shredded marsh grass, which could have been constructed by no other mammal than one of these tiny shrews. The nest was somewhat smaller than a baseball and flattened above.

In central and western New York, these shrews have been collected in orchards, open fields with a thick cover of grass, in the basement of houses, and gardens grown to dense masses of pigweed and smartweed. In many thousands of trap-nights in wooded areas, not a single *Cryptotis* has been taken in such a habitat. However, Lyon (1925) records *Cryptotis* from northern Indiana in moist woods, not far from a clearing. In company with this shrew were *Blarina* and *Peromyscus*, all three living in leaf mold tunnels. The Komareks (1938) found this little shrew occupying fallow fields at low elevations and in the runways of *Synaptomys cooperi stonei* in open grassy patches along the forest margin at an elevation of 2730 feet in the Smoky Mountains of Tennessee. This is the highest elevation in the United States at which *Cryptotis* has been recorded.

MEASUREMENTS, WEIGHTS AND MOULT

Measurements of 12 New York and Virginia specimens average: Total length, 81.9 (92–75) mm, tail, 17.5 (21.5–15), hind foot, 11.2 (12.5–10). Adult weights vary from 4.4 grams to 5.7 grams.

A captive shrew, which I kept for several months, commenced moulting on September 17. The moult started on the face and progressed rapidly over the head to the shoulders, being replaced by the darker winter pelage. At the same time an area on the rump about the size of a small pea commenced to shed and similarly an area of comparable size on the mid-belly. The moulting areas remained well defined for five or six days, then the lines of demarcation were lost in the general renewal of fur. The winter pelage is darker, the upperparts lacking the sepia-tipped hairs of the summer fur. An adult male collected in the Okefinokee Swamp of southeastern Georgia on August 26, 1922, indicates a well marked moult, this being particularly well marked on the facial region and just behind the shoulders. On March 25, 1940, I took an adult male *Cryptotis p. floridana* at Fort Myers, Florida, that had replaced about half of the dorsal winter pelage with the shorter summer pelage. There is little seasonal color difference in this subspecies, at least in south Florida.

Apparently *Cryptotis* moults without regard to season, although the moult appears to occur more commonly in the late spring and late fall.

FOOD

There is little reason to believe that the food habits of *Cryptotis* should differ from its larger relative *Blarina*, whose dietary is comparatively well known. I have examined the stomach contents of 12 *Cryptotis*. These contained fragmentary insect remains, earthworm fragments, centipedes, mollusc remains, and a

small amount of vegetable matter. The insects included Coleoptera (Carabidae, Scarabidae and unidentified beetle larvae). On Chincoteague Island, Virginia, I found little piles of snails, *Melampus lineatus* Say, in the runways of *Oryzomys*. In these runways I trapped *Cryptotis*. The fact that the whorls were eaten away suggests that *Cryptotis* gathered them as food. A captive shrew opened the shells in much the same fashion as those that had been found in the runway.

Observations of captive specimens add slightly to our meagre knowledge of the food habits. Peterson (1936) records an individual consuming 21 mealworms, 2 beetles (*Tenebrio molitor*) and a cockroach, within an hour after it was received, thus upholding its record as a glutton. Springer (1937) observed that a *Cryptotis p. floridana* ate an average of 5.5 grams of food during a 24 hour period for 33 days. The shrew weighed but 5 grams. Mealworms, other insects, amphibians, lizards and mice constituted the larger share of the food.

The apparent fondness of this species for frogs, and the method employed in hamstringing the patellar tendons of these amphibians suggested to Hatt (1938) that possibly these shrews fed only upon cold blooded vertebrates and insects, inasmuch as captive shrews refused young mice.

Evermann and Butler (1894) refer to this species as the bee shrew, stating that it occasionally enters the hives and there builds its nest, feeding upon the brood.

It has been my good fortune to have several of these shrews in captivity for periods varying from three weeks to four months and thus to learn something of their behavior and feeding habits. One that I [illegible] for three months was observed almost daily, and the manner and amount of food eaten was recorded. This shrew was fed cockroaches, wireworms, carabid beetles, cutworms, white grubs, sowbugs, snails (*Polygyra*), small mammals, a mixture of sardines, salmon, peanut butter and oatmeal flakes, and various table scraps such as meaty bones, bits of fish and cooked vegetables. It was certainly not a fastidious feeder, eating nearly every item offered it. For several periods of 10 days each, every item of food was carefully weighed before feeding, and any not eaten was removed. In this manner some note of the quantity consumed by this particular shrew was obtained. During one such period, the shrew, which averaged 4.7 grams, ate 3.6 grams of food, or approximately three-fourths of its own weight daily. It was offered a variety of natural foods during this period, and always had sufficient before it to exercise some choice. This amount, while incredibly large for any animal to consume during such a short period, is somewhat less than that recorded by other observers. While it is unquestionably true that shrews do eat prodigious amounts of food, Blossom (1932) has recorded a captive *Sorex cinereus* eating 3.3 times its own weight daily for a week, it is probable that in the wild state, where *natural foods* are readily secured and a wide choice exists, shrews do not consume such quantities. This appears partially substantiated by feeding experiments with captive animals. I have noted where the animals are fed a variety of natural foods, in contrast to the common kitchen foods of man, they eat much less. Captive shrews were very fond of apples, eating all but the skin and core. *Blarina* is likewise fond of apples and this fact makes it a rather simple task to feed such captives.

The rate of digestion is exceedingly rapid. This was determined in the following manner. On various occasions my shrews were fed for several days on a diet of mice alone. During this feeding, they would be offered a small piece of mealworm, a housefly or some chitinous body that could be recognized in the feces. By removing the slightly damp sphagnum moss from the nest box and enclosure, and substituting white paper on the bottom of the aquarium, the feces could be recovered as soon as they were deposited. This was done, the time of defecation noted, and the droppings examined. The time of appearance of the chitinous remains was checked against the time such was eaten by the shrew, and in this manner the period necessary for the passage of the food was obtained. A similar procedure was adopted in feeding shrews a bit of mouse flesh in which hair was imbedded, after a continuous feeding of snails and apples. In this manner it was possible to check the rate of digestion.

In one instance, passage of chitin through the animal took 95 minutes. On another occasion, the passage of hair took 114 minutes. These were the fastest times; we have other records of approximately 3 and 4 hours for the passage of food through the alimentary tract.

Every *Cryptotis* that I have observed drank freely, particularly so when the food was of a dry nature. Presumably they must go without water upon occasion in their natural habitats, for during exceptionally dry periods of the summer, these shrews may occupy habitats where scarcely any dew occurs.

REPRODUCTION

The reproductive behavior of shrews is but poorly known; this is particularly true of American species. The new born young of but two species has been described, *Blarina brevicauda* (Hamilton, 1929) and *Sorex cinereus* (Blossom, 1932).

The breeding season of *Cryptotis*, so far as we are aware, extends from early March until November, at least in the northern limits of its range. In Florida it may occur throughout the year. An adult male *floridana*, which I took on March 25, 1940, at Fort Myers, Florida, had enlarged testes, while the following day an adult female was collected that showed no indication of breeding activity. A female taken on April 5, 1933, at Ithaca, New York, contained five 6 mm embryos. A pregnant female secured on July 1, 1941, at Chincoteague, Virginia, gave birth to six young on July 5. On November 2, 1934, I took a female and her 5 young alive, these being approximately five days old. They were subsequently raised and kept captive for several months.

The Komareks (1938) record a female *Cryptotis* collected on October 16 that was through nursing, implying that it had recently nursed, and four males collected on October 20 that had enlarged testes.

From these records we may conclude that the breeding season commences not later than mid-March and extends into early November in northern latitudes.

Description of Young.—Of the female referred to earlier, which I took at Chincoteague, Virginia, on July 1, her swollen abdomen gave every indication of advanced pregnancy. During the morning of capture, I placed her in an aquar-

ium in bright sun in order to secure a picture, but the results were not favorable. Her incessant activity, alternating with period of exhaustion, in which she appeared near death on several occasions, prompted me to give up photographic

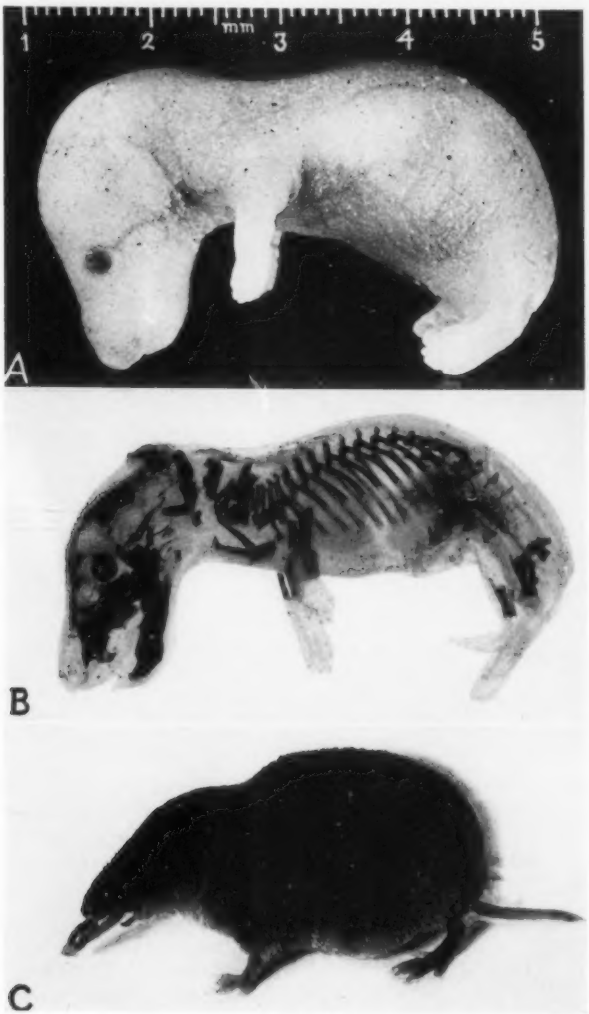

PLATE 1

A. New born *Cryptotis*. B. Alizarin stained cleared specimen as in A, showing skeletal development at birth. C. Adult female *Cryptotis* eating a mealworm, photographed a day before she gave birth to six young.

efforts and attempt to keep her alive if possible. While I have kept many shrews in captivity, none took such rough handling and survived as did this individual. On July 3, the shrew, which weighed 6.3 grams, was photographed (Pl. 1, C). The following night (sometime between 10 p.m. on July 4 and 7 a.m. July 5) she gave birth to six young. On the morning of July 5 she weighed 4 grams. As soon as the litter was discovered, one young was removed, photographed, measured, described and preserved. During the removal, the mother showed extreme solicitude for her brood, running about excitedly, making feeble nips at my fingers and in other ways demonstrating her extreme agitation.

The recently born young had already nursed, and from the shrunken appearance of the umbilical stub, was probably about 8 hours old. It weighed 0.32 grams and had the following measurements: Total length, 22 mm; tail, 3; hind foot, 2.5. Mystacial vibrissae were present but very small. The toes were all separated with small but distinct claws. This specimen was cleared and stained in alizarin in order that the skeletal system might be studied. No indication of developing teeth can be noted in either jaw. The skull measures 7.4 mm; the dentary, 4 mm. As may be seen in the accompanying illustration (Pl. 1, A, B) the fore limbs are much better developed than the hind limbs.

This litter was nursed by the parent for two and a half days, at which time they were deserted.

On November 2, 1934, a dog uprooted a nest of *Cryptotis* near Ithaca, New York, and I removed a nursing female and her five young from this nest. On the basis of development in *Blarina* (Hamilton, 1929), I judged the young to be 5 days old. The young averaged 1.3 grams. They were covered dorsally by a fine pubescence that gave a silvery lustre to the back. Ventrally the young shrews were pink and quite devoid of hair. They developed rapidly, gaining from a tenth to a fifth of a gram daily until they were approximately three weeks old, at which time they averaged 3.4 grams each. Their eyes were open, the incisors well developed and the little shrews had all the appearance of adults except for their somewhat lesser size and the sleeker, juvenile coat.

Welter and Sollberger (1939) have mentioned a litter of six nursing young, whose combined weight exceeded that of their parent three times. No less remarkable was the prodigious feat of the parent shrew under my observation, which, weighing but 5.4 grams, supplied sufficient milk to nourish and develop five young whose combined weight just prior to weaning exceeded that of their mother by slightly more than three times. When these young shrews were a month old, their dentition was complete, their activity and food requirements apparently no less than that of the parent, and to all outward appearances they were fully grown.

BEHAVIOR

The several *Cryptotis* that I have kept in captivity have been housed in large wash tubs with several inches of rotted leaf mold in the bottom of the tub and a small cardboard box as a nest chamber. They were kept in a dark, cool fruit cellar during the winter months and in a dark corner of the cellar during the sum-

mer. Under such conditions shrews thrive well, and their actions can be observed with ease.

Senses.—Sight appears to play only a minor role in the life of *Cryptotis*. The eyes are minute, small even in proportion to the rest of the diminutive body. Movements are apparently not directed by the eyes, for objects moved about only a few inches from the head, in line of vision, elicit no response by the shrews.

Smell likewise appears not to be particularly well developed. Small objects, as millipedes, which normally give off a pronounced odor, were placed in a small aquarium with a hungry shrew; it was several minutes before the shrew found them. Apparently these shrews rely chiefly upon a well developed tactile sense, organized in the sensitive snout and vibrissae, for the animals will all but blunder into their food before it is sensed.

Hearing is not particularly well developed unless it be for supersonic sounds. Shrill whistles, squeaks and a spoon struck on a pie tin elicit little notice. These shrews are sound sleepers, and when coiled in their nest box exhibit no concern for various noises.

Cryptotis is active at all hours. No rhythmic activity has been noted in captive individuals. A group of five housed together in an unheated room during December were more active by night, running over the leaves of their enclosure and occasionally emitting tiny squeaks. When fed to repletion and their abdomen greatly distended with food, these shrews will sleep for six or eight hours, but they are seldom quiet for such a long period.

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AN ECOLOGICAL STUDY OF TREE SQUIRRELS IN EASTERN TEXAS

By Rollin H. Baker

Squirrels are an important game species in eastern Texas, being, according to Goodrum (1938), hunted more than any other game mammal or bird in the region. Much of the hunting is done in hardwood timber along the larger creeks and rivers where gray squirrels (*Sciurus carolinensis carolinensis*) are the dominant species. Fox squirrels (*Sciurus niger ludovicianus*) are more generally found along the smaller creeks and in upland pine and hardwood timber. Sportsmen consider the gray squirrel to be the more favored game.

With the increase in the number of squirrel hunting clubs and the greater interest in the conservation and management of squirrels in eastern Texas, it has become necessary to learn more concerning squirrels and their habitat requirements in an effort to deal more effectively with problems relating to this important game species. Goodrum (1937a, 1937b, 1938, 1940) has presented a considerable amount of information on squirrels in eastern Texas, and the purpose of this study is to gain further data on certain phases of his original work. Field investigations were conducted during the period from August 1940 through August 1942, much of the work being done in connection with other field activities.

STUDY AREAS

Squirrel studies were made in the wooded bottom and hammock country of the Neches River in Tyler, Polk, Angelina and Trinity counties. Intensive investigations were carried on at the Piney Creek Deer and Turkey Project, Polk and Tyler counties. This 50,000 acre refuge borders on the Neches River and includes the mouth of Piney Creek, the junction of the latter and the Neches River forming a wide overflow area. The uplands, formerly a forest of longleaf pine (*Pinus palustris*), now contain open woodlands of second growth longleaf together with shortleaf (*P. echinata*) and loblolly pine (*P. taeda*) and post oak (*Quercus stellata*), black jack oak (*Q. marilandica*), and sweet gum (*Liquidamber styraciflua*).

The river bottom forest consists of fairly open, mature hardwood timber, second growth over much of the area. Water oak (*Q. nigra*), willow oak (*Q. phellos*), overcup oak (*Q. lyrata*), cow oak (*Q. prinus*), sweet gum, black gum (*Nyssa sylvatica*), pignut pecan (*Hicoria aquatica*) and cypress (*Taxodium distichum*), are the dominant larger trees. Smaller trees, including water ash (*Fraxinus caroliniana*), water elm (*Planera aquatica*), and mayhaw (*Crataegus* sp.), are present. Undercover, consisting formerly of thick stands of switch cane (*Arundinaria gigantea*), is not abundant. Grapes (*Vitis* spp.) and green brier (*Smilax* sp.) form ground cover in some instances though generally forming entanglements around trees.

Between the upland "piney woods" and the overflow area and often interspersed in the bottoms are sandy ridges or hammocks not subject to overflow and containing a thick vegetation of a variety of species. Loblolly and short-

leaf pine, sweet gum, magnolia (*Magnolia grandiflora*), evergreen oak (*Q. rhombica*), white oak (*Q. alba*), water oak, and red oak (*Q. rubra*) constitute the larger timber found in this association. Smaller species are blue beech (*Carpinus caroliniana*), iron wood (*Ostrya virginiana*), mulberry (*Morus rubra*), holly (*Ilex opaca*), maple (*Acer rubrum*), redbud (*Cercis canadensis*), and dogwood (*Cornus florida*). Understory is thick and includes huckleberry (*Vaccinium virgatum*), French mulberry (*Callicarpa americana*), grapes, green brier, and other shrubs and vines. Little herbaceous vegetation is present.

The area included in the Piney Creek Deer and Turkey Project is owned by lumber companies. It has been fenced by individuals for the grazing of cattle and hogs, the lumber companies welcoming such arrangements which tend to reduce timber thefts and fires. The wildlife rights were secured by the Game, Fish and Oyster Commission for a development project in 1939. Prior to this time hunting was limited and regulated, enabling a high squirrel population to exist. Under supervision of the Game, Fish and Oyster Commission only a minimum of squirrel hunting has been allowed. It can be justly stated, therefore, that the squirrel population has been relatively undisturbed for a number of years and that a near carrying capacity density has existed in the area throughout the study period.

The number of cattle and hogs on the project area varied from year to year, but the average estimated population was about 200 head of each on approximately 5000 acres. Cattle, although doubtless grazing reproduction of mulberry, ash, and other food trees, were not considered a particularly detrimental factor to the squirrel habitat in this situation. Hogs, however, were in direct competition with squirrels as well as deer and turkey for fall and spring mast crops.

METHOD OF STUDY

In an effort to obtain information on squirrel activity and population density, four quadrats, each five acres in size, were marked off in August 1940 at the project area. Of these, two were used for detailed study. Data for this paper were obtained principally by the use of the time area method of censusing and observing squirrels at the two quadrats. This method, described by Goodrum (1937a), consists of quietly observing squirrels from observation stations selected at random for periods of 30 minutes during early morning. Counts were made from daylight to as late as two and one-half hours after sunrise. Considering the point of observation as the center of a circle, a semi-circular area could be viewed easily without moving and only squirrels that appeared in the area were counted. By measuring the average distance seen, the area observed could be figured. With the record of the squirrels seen and the size of the area observed known, the number of squirrels to the acre was calculated. As many as five counts were made during a single morning, five observation stations being easily found in the quadrats since only about 0.2 to 0.5 of an acre could be viewed at a time. Larger areas could be viewed in winter as visibility was increased because of an absence of leafy vegetation.

Both Goodrum (1940) in Texas and Chapman (1939) in Ohio and other workers have used this method to determine gray squirrel populations while Baumgartner (1938), working in Ohio, found this method undesirable for counting fox squirrels in unpastured woodlots where the visibility was poor. Hamilton (1939), studying the red squirrel in New York, made somewhat similar observations to determine squirrel activity. The writer found this method of census to have certain objections as well as good points. Rather than giving definite population figures, it presented more of a relative picture of visible population trends from month to month or season to season. The more the counts the more reliable were the results. During the 25 months study period, a total of 564 time area counts were made at the quadrats or about 22 counts each month.

During a count it was possible to record a single squirrel two times, due to the fact that it could be seen in one part of the observed area and disappear to reappear in another part of the field of vision. The use of field glasses partly remedied this, at least by determining species and sometimes age and sex. However, since there were squirrels that entered the observed areas but were not seen, it is possible that these two factors tended to cancel each other. An advantage of this census was that observations on the food habits, activity, and breeding habits could be obtained at the same time active populations were recorded. The large number of counts tended to cut down on the inaccuracy caused by the difference in squirrel activity from one morning to another. Squirrels were less active following a rain or during windy weather. As a result practically all counts were made on dry quiet mornings.

The writer is indebted to Cleddie Pate, refuge keeper at the Piney Creek Deer and Turkey Project during 1940 and 1941, for his cooperation and to Mary W. Baker for her help in making time area counts.

QUADRATS

Under the original plan, four plots, five acre in size, were marked, two being in pure hammock type and two in mixed bottom and hammock type. Of these, one in each type was fenced in August and September 1940 to study the effects of hog exclusion. Since the fence containing part bottom land was continually washed out by overflow waters, this idea was abandoned and study was concentrated on only two areas. Squirrel live trapping was done at the quadrats for a short time in the fall of 1940, and several squirrels were caught, tagged and released. However, other field studies prevented a continuation of this program.

In the original selection of the quadrats care was taken to mark typical areas. The results of the study, therefore, may be considered indicative of squirrel populations in other forested river bottom and hammock country of eastern Texas of similar type.

Of the two quadrats selected for intensive study, one, Pin Oak Point Quadrat, was located in a mixed bottom and hammock area. The plot consisted of a projection of hammock type into bottomland. A slough ran through one side of the quadrat furnishing a water supply except during very dry periods. In an effort to describe the vegetation, an analysis of the dominant trees was made.

At random 551 trees, one inch to one foot in diameter, breast high, were counted in the five acre plot. Of these 26.8 percent were blue beech, 25.7 percent ironwood, 12.7 percent ash, 7.2 percent sweet gum (reproduction), 5.8 percent holly and 4.7 percent dogwood. Others such as mayhaw, redbud and mulberry were counted but in smaller percentages. Of 238 trees, one foot to three feet in diameter, breast high, 21 percent were evergreen oak, 14.3 percent loblolly pine, 10.5 percent water oak, 9.6 percent sweet gum, 8.0 percent pignut pecan, 8.0 percent black gum, 6.3 percent overcup oak, 3.3 percent cow oak, 2.7 percent white oak and 2.5 percent magnolia. Hickory (*Hicoria* sp.), sassafras (*Sassafras variifolium*), willow oak, and other trees were found in smaller numbers. French mulberry, huckleberry, smilax, grapes and other shrubs and vines made up the understory vegetation in the hammock association with some switchcane present in the bottom type. The most conspicuous large tree adjacent to but not within the plot was cypress.

The other five acre study plot, Platt Field Quadrat, was located in pure hammock association. It was thickly vegetated and poorly drained. No permanent water was present, the nearest being some 300 yards away. During wet periods water collected in flats to remain until evaporated. Of 440 trees picked at random within the plot area, one inch to one foot in diameter, breast high, 27.5 percent were holly, 17.7 percent maple, 11.8 percent dogwood, 9.5 percent ash and 6.4 percent mulberry. Wild plum (*Prunus* sp.), chinquapin (*Castanea floridana*), redbud and other trees were also counted, but in smaller numbers. Of 351 trees, one foot to three feet in diameter, breast high, 30 percent were loblolly pine, 14.8 percent white oak, 13.4 percent black gum, 12.3 percent red oak and 9.1 percent water oak. Sweet gum, willow oak, and hickory were also counted. Grape, green brier, French mulberry, and other vines and shrubs grew profusely in the quadrat.

Deer mice and wood rats were common mammals in the two quadrats. Other mammals found were white-tailed deer, bats, raccoons, foxes, opossums, minks, armadillos, swamp and cottontail rabbits, and a few moles. Free ranging hogs were conspicuous members of the fauna. A variety of birds were observed, including red-shouldered hawks, herons, egrets, barred owls, and wood ducks, among the larger birds. Black vultures roosted near the Platt Field Quadrat, a nest with one egg being found under a fallen tree on May 16, 1941, near the quadrat. Ticks and mosquitos were abundant except during midwinter.

SQUIRREL POPULATIONS AT PIN OAK POINT QUADRAT

Figure 1 presents a summary of squirrel populations in the Pin Oak Point Quadrat as determined by time area counts during the study period. Counts were made in 22 of the 25 months, an average of about 12 for each month. Visible populations were found to range from a low of no squirrels seen in February and July, 1942, to a high of 12.12 squirrels to the acre in December 1940. The average population was 3.32 squirrels to the acre. High populations were reached in late summer and fall and in spring. Low points were found in winter and in late spring and early summer.

Beginning in August 1940, the visible squirrel population was found to rise to a peak in December. This peak was the highest recorded and appeared to be the result of the presence of an above average fall mast crop that offered a concentrated food supply for the squirrels. In late summer, squirrels were found feeding principally on a bumper crop of blue beech and ironwood seeds and to a lesser extent on the mast of loblolly pine, black gum, pignut pecan, hickory, and overcup oak. As the acorn crop ripened in late September and October, squirrels began utilizing it extensively and were found concentrated in oak groves in November and December. This high density was also found in bottom habitat along the Neches River in Trinity County in October and November where 66 time area counts in oak flats showed the presence of about 10 squirrels to the acre. Overcup, evergreen, water and willow oak appeared to be the favored species. White and cow oak acorns were eaten, although to a

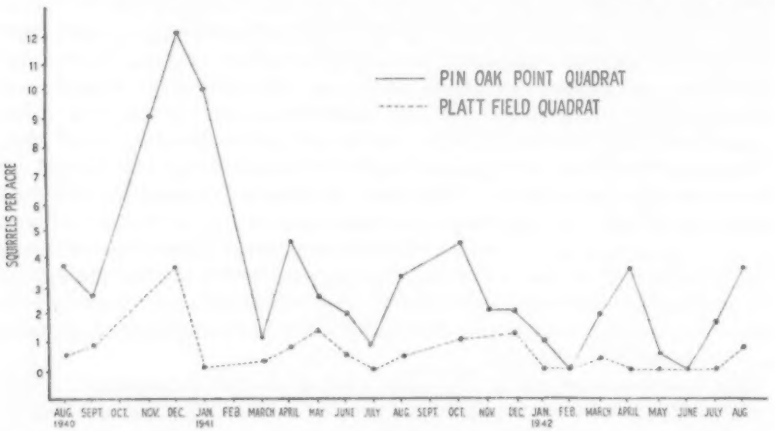

FIG. 1. Squirrel population fluctuations at the study quadrats as determined by time area counts.

lesser extent. A drop in activity in the winter months appeared correlated with a decline in the food supply, which was reduced not only by heavy utilization by wildlife but by flood waters that filled the bottom in late November, covering a considerable part of the fallen acorn crop. In addition, the retiring habits of pregnant females following the rut and the tendency for squirrels to hole up in winter were factors influencing activity. The low point was reached in March followed by a rise in activity during the spring months. Populations appeared activated by the presence of a new food supply consisting of buds, blooms, insects, lichens, and various fruits, including mayhaw and mulberry. Acorns were still being used by gray squirrels that dug fall caches. Since flood waters remained in the Neches River bottom until summer, squirrels had an opportunity to feed on acorns all during the period, because water level fluctuations permitted acorn drifts to become uncovered from time to time. Under usual conditions flood waters were gone by March or April.

In July, visible squirrel populations reached a summer low. The small density may have been due to a lack of concentrated food as well as to inactivity of the squirrels in hot weather, especially of gravid females, following the spring rut. The presence of a new food supply appeared to be the factor activating the late summer and fall squirrel population as in the case of the previous year. However, a decline is noted in November and December that appeared to be the result of a short acorn crop. The major part of the small food supply was exhausted early in the fall. Populations continued to drop in winter to a low in February. Squirrel activity increased during the early spring but declined more in following months than did populations for the previous spring. The new growing foods did not appear reduced; however, there was a conspicuous absence of a left-over supply of acorns as in the case of the former spring. This factor may have been responsible for the more rapid reduction in the visible population. In June a low point occurred, followed by a rise in activity in the summer months with the prospects for a fair to good mast crop.

SQUIRREL POPULATIONS AT PLATT FIELD QUADRAT

Figure 1 also summarizes the squirrel population at Platt Field Quadrat during the study period. Counts were made during 20 of the 25 months, an average of 15 counts for each month. Visible populations ranged from a low of no squirrels seen in July, 1941, January, February, April, May, June and July, 1942 to a high of 3.78 squirrels to the acre in December, 1940. The average population was 0.61 squirrels to the acre or about one-fifth of the average found at Pin Oak Point Quadrat. Population peaks were noted in late summer and early fall and in spring. Low points were observed in winter and in late spring and early summer. During the winter and spring of 1942 visible populations were too low to give definite conclusions. Otherwise, high and low peaks were similar to those found at Pin Oak Point Quadrat, the only difference being the smaller densities recorded at Platt Field.

Visible populations, beginning in August 1940, increased to a high point in December. Loblolly pine seeds appeared to be the main source of food in late summer. In the fall months, acorns were utilized. However, at Platt Field there was a conspicuous absence of the fine stands of acorn producing trees that were present at Pin Oak Point. This factor apparently made the difference between the population at the two areas. A fair crop of red oak acorns and some white and water oak acorns were available. It was apparent that these foods were exhausted rapidly as there was an abrupt drop in activity in winter. It is likely that holing up tendencies were partly responsible for this decline as in the case of Pin Oak Point. A spring peak in activity was noted in May with the presence of a new growth of food in the form of greens, fruits, and insects. There was some use made of uncovered acorns. A low point was found in July followed by a gradual rise in activity through December. As in the case at Pin Oak Point, a smaller acorn crop was instrumental in reducing the visible squirrel density from the higher peak found the previous year. Following the fall peak, there were practically no squirrels observed during the spring and summer of 1942. This does not necessarily mean no squirrels were

present, but it does indicate a low and inactive population. In August, a rise in activity was observed in correlation with an increase in the food supply.

SQUIRREL ACTIVITY

Figure 2 summarizes the squirrel activity as affected by the time of morning. Time area counts made are divided among three morning periods of one hour each beginning at one-half hour before sunrise. They show that there was a gradual decline in squirrel activity from the earliest to the latest time period indicating that squirrels became less active as the day advanced. During the warmer spring and summer months a more obvious decline was noted than during the colder fall and winter.

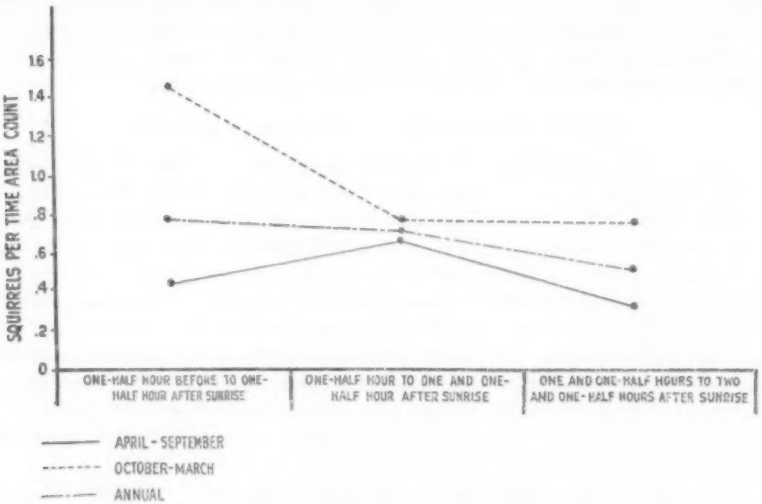

FIG. 2. A comparison of the effects of the time of day on squirrel activity.

Information obtained from the time area counts appears to indicate that squirrel populations were influenced by the food supply, especially the fall acorn crop. Squirrel activity was found to vary from season to season and even from month to month within the study plots as an apparent result of the presence or absence of acorns. Spring foods were found to fluctuate less. The presence of a left-over part of the fall acorn crop of 1940 apparently was a principal factor causing increased squirrel activity during the spring of 1941 as compared with the spring of 1942. Fluctuations in the available food supply were found to cause squirrels either to become inactive or to disperse in search of food. Inactivity was apparently a principal cause for the recording of low visible populations in winter and in late spring and early summer. However, during fall and probably early spring when concentrated foods were present, there appeared to be a defi-

nite move by squirrels to better feeding areas as is indicated by the high population found during the fall of 1940 at Pin Oak Point Quadrat. This number not only included the resident population but apparently contained a transient group as well, the latter squirrels perhaps residents of nearby areas not containing as choice a selection of food. No evidence was obtained to substantiate this assumption, however.

It was probable that the inactivity of squirrels during the winter was due to holing up brought about partly by the absence of abundant food and by the normal tendency of fattened squirrels to den during the cold weather. Low points in late spring and early summer may also have been due to a scarcity of a concentrated food supply as well as to the tendency of squirrels to become quiet in the warm weather. The semi-annual rutting periods centered in May and December were found to activate populations, but a reduced activity was noted following the rut, because of the retiring habits of gravid females. This appeared correlated with the winter and the late spring and early summer low points. Young were weaned at a time when food conditions were good, in late March and April and in late August and September.

RATIO OF GRAY AND FOX SQUIRRELS AT THE STUDY QUADRATS

During time area counts at Pin Oak Point Quadrat, 333 squirrels were found, 228 gray, 31 fox and 74 unidentified squirrels. This indicated a ratio of gray to fox squirrels at the quadrat of 7.3:1. At Platt Field Quadrat 58 squirrels were seen during the study period including 24 gray, 15 fox and 19 unidentified squirrels, giving a ratio of gray to fox squirrels of 1.6:1. These ratios bear out studies of other workers in showing a larger population of gray squirrels in mixed hammock and bottom habitat and a more evenly divided population in pure hammock habitat. The latter type has a greater resemblance to upland habitat where fox squirrels are more abundant. However, these conclusions may not necessarily be applied to all river forest habitat in eastern Texas. Although gray squirrels were probably dominant in most of these areas originally, timber cutting and other environmental changes have occurred encouraging fox squirrel populations, in some instances to a point where they outnumber the less adaptable gray.

Figures 3 and 4 summarize the seasonal differences in gray and fox squirrel numbers at the two quadrats. Figure 3 shows that at Pin Oak Point Quadrat the ratio of gray to fox squirrels was rather constant. During the fall and winter months, however, there was an increase in the number of fox squirrels. This was apparently due to an influx of fox squirrels caused by the presence of an attractive mast crop. Figure 4 indicates the ratio at Platt Field Quadrat. Fox squirrels were found to be numerous in the summer months and to outnumber the gray squirrels in the fall. This condition appeared correlated with the presence of ripe pine mast, which may have attracted fox squirrels from the adjacent uplands. The winter and spring ratio indicates a greater number of gray squirrels, which is undoubtedly more indicative of the resident population.

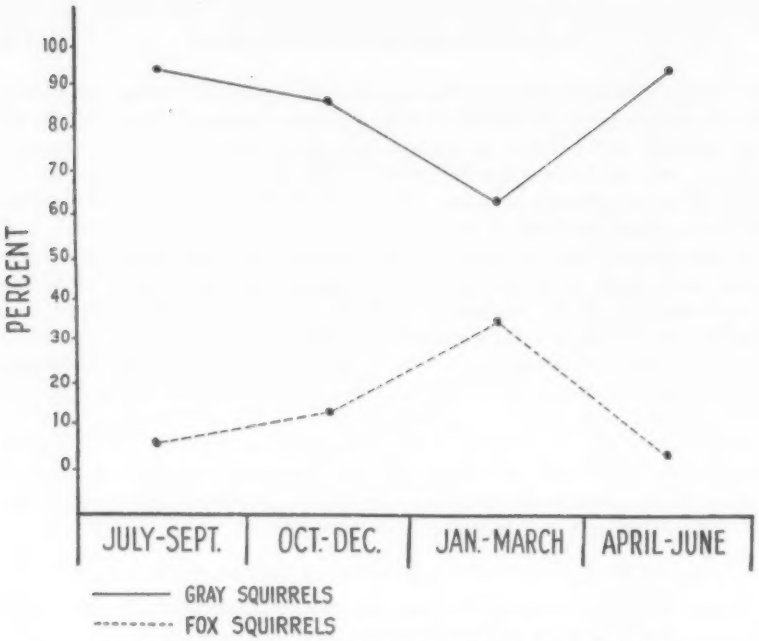

FIG. 3. Ratio of gray to fox squirrels at Pin Oak Point Quadrat.

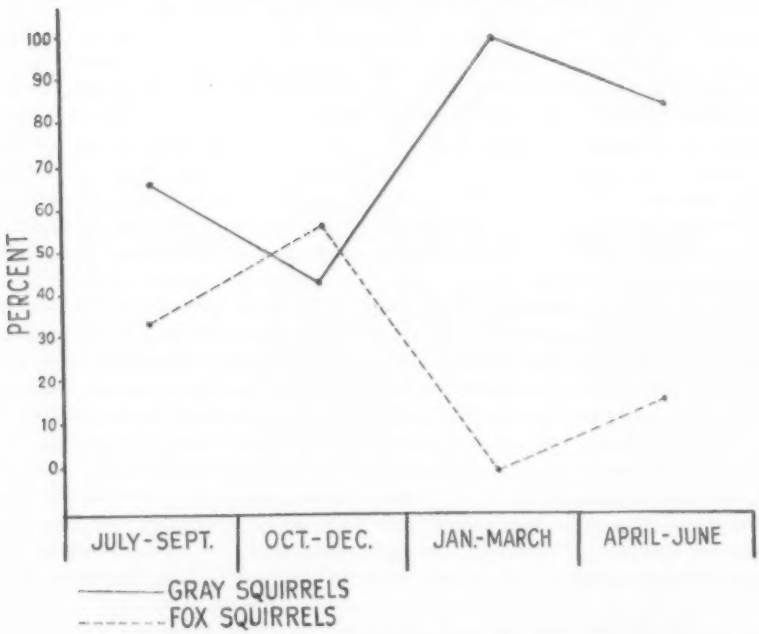

FIG. 4. Ratio of gray to fox squirrels at Platt Field Quadrat.

SQUIRREL BEHAVIOR DURING RUT

Squirrels in rut were observed or reported for nearly every month of the year at the Piney Creek refuge. This year-around sexual activity was noted by Goodrum (1938). Groups of rutting squirrels were conspicuous and could be detected some distance away by their noisy movements through the trees and their vocal sounds. During a peak in the rut, squirrels often remained active throughout the day. Reports of activity on moonlight nights were received but not verified. Squirrels were found to pay little attention to observers; this fact probably being used to advantage by hunters. Encounters with rutting squirrels were not uncommon, but during a time area count at Pin Oak Point Quadrat in July 1942, a group of rutting gray squirrels was observed at close range.

At first only one or two scattered squirrels were seen. There was an occasional barking or purring sound. Presently several sucking or kissing noises were heard, and eight squirrels were observed racing through a grove of four or five large trees. They were chasing each other, and it was apparent that there were at least two or three female squirrels in heat. The females were being chased by the males, but because they made rapid escapes, it was assumed that they were not ready for service. Presently a female received a male. She was hanging on the under side of a small limb with the male grasping her. The limb bent down under the weight of the two squirrels, but this precarious position did not seem to disturb them. The male had just mounted the female when another squirrel approached, probably a second male. The first male immediately left the female to chase the other squirrel away. On returning the female was gone. Whether the squirrels had completed copulation during the short act was not known. Other observers have found squirrels to copulate for periods from 30 seconds to one minute in length. During this period of activity the squirrels were gradually moving away until a short while later they had disappeared from view.

FOOD HABITS

It was observed that when squirrels fed on small mast such as ironwood, blue beech, and black gum the food was eaten in whatever position the squirrels assumed to reach it. When larger mast was eaten, including acorns and pine mast, the food was carried to a limb where the animal was able to sit upright. When finished and another item procured, the squirrel usually returned to the same place to eat it.

Squirrels were found to drop a tremendous amount of food when feeding in trees. Instead of retrieving the fallen items, others were obtained, allowing the ground under oak, hickory, pignut pecan, and pine trees to become littered with half eaten mast. However, what was not eaten by bluejays, other wildlife, and hogs was later picked up by squirrels when the tree supply gave out.

During the fall of 1940, gray squirrels were found to bury a considerable amount of acorns. These were placed in small holes, and the dirt patted over them. Freshly buried acorns were easily located by the prints of the front feet

of the squirrels on the patted dirt. In the spring months, small holes dug in the same areas indicated that the gray squirrels had returned for their stores. It was not determined whether fox squirrels buried acorns.

When frightened during feeding, a squirrel was more likely to hold an acorn or other food item in its mouth rather than to release it when escaping. Several squirrels examined in hunters' bags during the fall of 1940 still retained acorns in their mouths.

LEAF AND TWIG NESTS

Figure 5 compares the number of inhabited leaf and twig nests to the number of squirrels seen during time area counts at the quadrats. Only counts in which

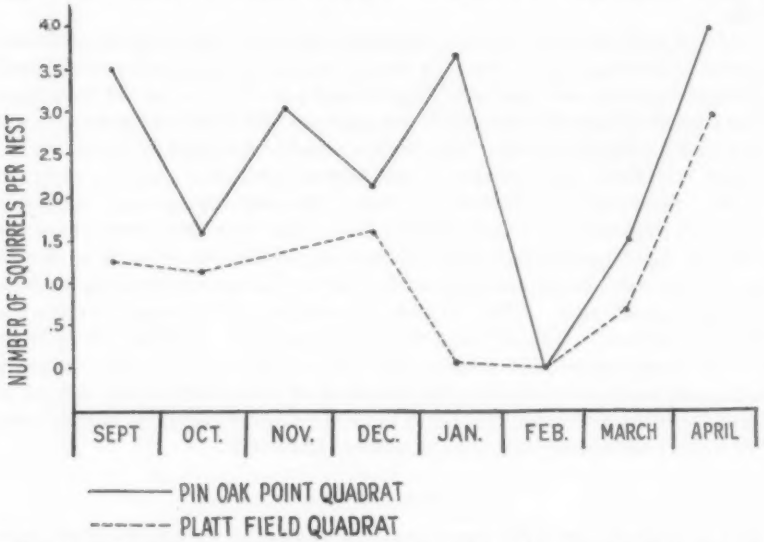

FIG. 5. Comparison of the number of squirrels to leaf and twig nests at the quadrats as determined by time area counts.

nests were found are included. The four months, May through August, are excluded from the data because of possible error in counting nests in the thick, leafy vegetation present during that time.

At Pin Oak Point Quadrat late summer and fall figures indicate a rather even curve for the number of squirrels to nests. This is continued through the first winter month to drop abruptly in February and rise again to an April figure comparable to late summer and fall figures. A somewhat similar curve is found for Platt Field Quadrat, although at Pin Oak Point there is an average of about two squirrels for each nest; at Platt Field, about one squirrel for each nest.

The curves give some indication that squirrels use a rather constant number of nests in a given area, at least during the periods of activity in late summer and fall and probably also in spring. This conclusion may or may not pertain to the

winter period, since time area counts did not provide as true a picture of the resident population during this time as during the fall period when activity was greater. The presence of seemingly inhabited nests during the winter months, however, indicates definitely the presence of an inactive population. This is additional evidence that actual squirrel populations are more stable throughout the year than is indicated by the observations of active numbers.

The difference in the figures for the two quadrats (about two squirrels to one nest at Pin Oak Point and about one squirrel to one nest at Platt Field) appears to be due to habitat differences. Field investigations indicated the presence of fewer hollow den trees at Platt Field, which may be the reason for the greater utilization of nests by squirrels there. It is probable that squirrels used leaf and twig nests less during the winter period and to a greater extent during the warmer months. Hollows may have been inhabited more in winter, although squirrels were found at favored den trees at all times of the year. Chapman (1939) remarks that in southeastern Ohio about 90 percent of the gray squirrels are born in tree dens; about 10 percent in leaf and twig nests. General observations in eastern Texas indicate that a larger percent are born in leaf and twig nests. Several reports from hunters and one summer sight record of very young fox squirrels in a leaf nest offer evidence of this, although it is possible, as Goodrum (1940) states, that some of these records may have been of young transferred to leaf and twig nests from hollows by the mothers.

Although no effort was made to record them, only a small percentage of inhabited leaf and twig nests were newly constructed. Generally old nests were kept in good repair. For example, at Pin Oak Point Quadrat in August 1942, only one out of nine inhabited nests was of new construction. Allen (1942) found fox squirrels in Michigan to rebuild many old nests. Apparently the same leaf and twig nests were often used throughout the year. No evidence was obtained of squirrels building nests primarily for one season or another; however, more data are needed to draw a definite conclusion.

Squirrels appeared to show little preference in the choosing of trees in which to construct nests and usually the more abundant trees were selected. At both quadrats squirrels preferred trees larger than one foot in diameter, breast high, only 22 percent of the nests being found in trees smaller than these dimensions.

At Pin Oak Point Quadrat, 68 old and new nests were found, 34 percent in evergreen oak, 22 percent in water oak, 17 percent in ironwood, 6 percent in pine and smaller numbers in blue beech, pignut pecan, sweet gum, black gum, overcup oak and others. At Platt Field Quadrat 26 nests were observed, 27 percent in pine, 14 percent in water oak, 11 percent in black gum, 11 percent in white oak, 8 percent in holly, 8 percent in red oak, 8 percent in sweet gum and 4 percent in elm.

WEIGHTS AND MEASUREMENTS

During October and November 1940, weights and measurements of gray and fox squirrels were obtained. Squirrels examined were shot by hunters in hunting clubs along the Neches River in Polk, Trinity, and Angelina counties.

In determining average weights, the separation of sexually mature and imma-

ture squirrels was attempted. Rapid inspection of squirrels at checking stations did not permit critical examination of teeth, bone ossification, and reproductive organs. Males were considered summer immatures if the testes were abdominal and the scrotum was light colored and undeveloped. Females were judged to be summer juveniles if the teats were inconspicuous and small as compared with adult females having had young whose teats were larger and darker. Although more complete examinations would have been more desirable, it was concluded that the majority of the squirrels were segregated into the correct age classes.

Table 1 presents October and November weights of 69 adult gray squirrels. The mean weight is 497 grams, with females outweighing the males by 12 grams. Table 2 shows the average weight of 50 sexually immature squirrels to be 355 grams. Again females outweigh the males. Assuming that most of the juveniles were born in July, the records indicate that the four or five months old squirrels were about 30 percent short of adult weight.

TABLE 1.—*Weights of 69 adult gray squirrels taken during October and November*

SEX	NUMBER	AVERAGE WEIGHT	MINIMUM AND MAXIMUM WEIGHTS
Males	40	492 grams	329 and 579 grams
Females	29	504 grams	321 and 590 grams
Totals	69	497 grams	

TABLE 2.—*Weights of 50 juvenile gray squirrels taken during October and November*

SEX	NUMBER	AVERAGE WEIGHT	MINIMUM AND MAXIMUM WEIGHTS
Males	18	324 grams	170 and 477 grams
Females	32	373 grams	170 and 508 grams
Totals	50	355 grams	

To learn the weight of a squirrel as compared with its dressed weight, 15 gray squirrels were weighed and then weighed again with the viscera removed (head, skin and feet intact). It was found that the loss was 17 percent.

The total length for 68 adult gray squirrels averaged 458 millimeters; length of tail averaged 214 millimeters. Fifty immature gray squirrels averaged 439 millimeters in total length, with a tail length of 218 millimeters. A difference of 19 millimeters in total length was found between adults and immatures, but tail lengths were found to be similar.

Table 3 attempts to correlate the weights and total lengths of 118 gray squirrels. There appeared to be a definite relationship between weights and lengths. Animals weighing from 151 to 200 grams had an average length of 372 millimeters. These were considered as kittens. Squirrels averaging from 201 to 250 grams measured 417 millimeters in length and were also considered as very young individuals. Weights from 251 through 350 grams averaged 432 and 442 milli-

meters and included the majority of the juveniles. Squirrels in the 351 to 600 gram weight classes showed rather constant length measurements averaging between 452 and 468 millimeters and were considered indicative of subadult and adult stages.

TABLE 3.—*Correlation of weight and length measurements of gray squirrels taken in October and November*

WEIGHT CLASS (GRAMS)	AVERAGE TOTAL LENGTH (MILLIMETERS)	NUMBER OF RECORDS
151–200	372	5
201–250	417	5
251–300	432	8
301–350	442	9
351–400	452	5
401–450	457	11
451–500	453	45
501–550	468	24
551–600	459	6

PARASITES

Goodrum (1937a and 1940) reports the presence of ticks, mites, and fleas as external parasites to squirrels in eastern Texas. In the fall of 1940, fleas and ticks were collected in Polk and Angelina counties from gray and fox squirrels. The flea, *Archopeas wickhami*, was quite abundant on both gray and fox squirrels examined in hunters' bags during November. The louse, *Neohematopinus* sp., was found on a few gray squirrels. Ticks were less common on squirrels at this time of the year. Specimens of *Amblyomma americana* and *Dermacentor variabilis* were taken from gray squirrels, and the former tick from fox squirrels. The flea and louse were identified by William L. Jellison; the ticks by R. A. Cooley.

Four gray and 12 fox squirrels, collected by the author in Angelina, Trinity, and Hardin counties, were examined by Asa C. Chandler for helminths. He reported his findings in the Journal of Parasitology (vol. 28, no. 2, pp. 134–140). Six forms of helminths were found including two cestodes, *Raillietina* (*R.*) *bakeri* and *Cysticercus tenuicollis* (in fox squirrels), and three nematodes, *Strongyloides robustus* and *Heligmodendrium hassalli* (in both gray and fox squirrels) and *Microfilaria alpha* (in fox squirrels). Another fox squirrel nematode, *Microfilaria beta*, from Harris County, Texas, was recorded in the same article.

MANAGEMENT

Regulating the kill has proved to be the most practical method for increasing squirrel populations in the extensive river forests of eastern Texas. This simple means has been practiced for as long as ten years or more by hunting clubs along the Neches River and has provided continued good hunting for members.

Most of these clubs are located in areas capable of holding high squirrel populations because of favored environmental conditions. However, there is a con-

siderable part of the river forest region where the squirrel habitat has been greatly reduced. Excessive logging of food and den trees has reduced the quality of the squirrel habitat, but there is promise of less drastic habitat reduction by lumber companies in the future, because of the greater use of selective cutting methods.

Overgrazing of mulberry, grapes, magnolia, beech, and other tree reproduction has played a part in the reduction of the carrying capacity. Large numbers of free-ranging hogs offer competition to squirrels as well as to other wildlife for the mast crops, especially the fall acorns. Many clubs have wisely reduced the number of livestock within their best hunting ranges.

It is found, therefore, that squirrel management in eastern Texas is not a question of habitat manipulation but rather a matter of the control of the human effects on the populations and environment. In order to show the results of proper regulations, one club that has kept accurate records is cited. This club on the Neches River in Angelina County voluntarily reduced the squirrel kill from the legal limit of ten to a limit of five squirrels a day and ten a week. The club members killed an average of about 500 squirrels a season during the years 1939–41. The area hunted covered about 5,000 acres, indicating a kill of one squirrel to ten acres. Most of the hunting was done in October, since in November and December, the other two months of the open season, efforts were directed more toward deer hunting. It is likely that the club could harvest one squirrel to eight acres or even more without seriously reducing the breeding stock.

Where squirrels have attained high populations, some hunting clubs have endeavored to harvest a greater number than in previous times. Fear has been expressed by club members that high squirrel populations utilize the acorn crops with great rapidity, reducing the amount available for deer, especially during a season of a short acorn crop. Investigations appear to indicate that there is a certain amount of competition among the species and that high populations of squirrels may reduce the mast available to deer and turkey. On the other hand, however, it is found that during seasons producing small acorn crops, there is usually an insufficient amount available for all animals, whereas during high mast periods there is often enough to fill the needs of every species, or as one woodsman remarked "when acorns are plentiful, there is more than enough and plenty always goes to waste anyway."

SUMMARY AND CONCLUSIONS

This paper presents an account of gray and fox squirrel populations as observed during time area counts at study plots over a period of 25 months, from August 1940 through August 1942, at Piney Creek Deer and Turkey Project in Polk and Tyler counties, Texas. It attempts to explain the fluctuations in these visible densities with the aid of observed food preferences and other life habits recorded at the time.

Squirrels were found to be considerably more abundant at the five acre study plot containing a mixed bottom and hammock plant association than at the plot containing a pure hammock plant association. The presence of a more favorable food supply appeared to be the reason for the higher population at the

former area. Population activity peaks were recorded in late summer and fall and in spring with low points in winter and in late spring and early summer. Time area counts did not necessarily present actual populations but rather visible ones, resident populations being more stable than indicated by the counts. However, during peaks, in population, which corresponded with high points in the food supply, it was apparent that local concentrations occurred; during low points, which corresponded to periods of food scarcity, some dispersion took place. It is concluded that squirrel activity is in part dependent on the available food supply, especially the fall acorn crop, and sensitive to any change in it.

Evidence indicated that squirrels were not so abundant as generally supposed on an acre basis throughout the large woodland tract. Although many acres contained favorable habitat for a large population, there was also much area possessing poor habitat. Also some spots were found to produce more food than others for a particular season. These are clearly demonstrated in the case of Platt Field Quadrat, a fair to poor hammock type and Pin Oak Point Quadrat, a good mixed bottom and hammock type.

Activity of squirrels was found to be affected by the time of day. They were more active early in the day, especially during spring and summer when the morning warmed up more rapidly.

Gray squirrels were found to outnumber fox squirrels in the mixed bottom and hammock area while there was a more even ratio in the pure hammock study plot. These observations bear out the studies of others in showing the presence of a dominant gray squirrel population in river bottom habitat while plant associations closer related to the upland type contain a larger number of fox squirrels.

It was apparent that the number of leaf and twig nests was at least partly correlated with the type of habitat and with the number of available hollow den trees. There were indications that a greater number were utilized in summer. No evidence was obtained as to whether fox squirrels used leaf and twig nests more than gray squirrels.

A definite correlation was found between weights and total length measurements in gray squirrels. No comparison was attempted with the fox squirrel records, since only a few figures were obtained.

A discussion of squirrel behavior during rut is given with a detailed account of the breeding activities of a group of eight gray squirrels.

A species of flea, a species of louse, and two species of ticks were found as external parasites on gray and fox squirrels. Two cestodes and four nematodes were found as internal parasites.

Regulating the kill was found to be the most practical method for increasing squirrel populations in eastern Texas. Hunting clubs have been able to maintain continued good hunting by practicing controlled harvest. Studies at Piney Creek further indicate that populations are especially vulnerable when concentrated during periods of heavy mast and during rutting periods, and that large groups do not necessarily indicate an equally high population throughout an extensive woodland.

Overhunting, together with the depletion of habitat by excessive logging and

overgrazing, have been factors contributing to the decline of squirrels in eastern Texas.

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OBSERVATIONS ON THE ECOLOGY OF THE GUNNISON PRAIRIE DOG IN COLORADO

BY WILLIAM LONGHURST

In connection with work on a graduate thesis, the writer carried on field investigations on the Gunnison prairie dog from June 27 to September 5, 1941, in Costilla County, Colorado. Observations were limited to the area in the immediate vicinity of Blanca and Fort Garland in the San Luis Valley and in the adjacent Sangre de Christo Mountains on the west side of La Veta Pass, especially along Trinchera and Wagon creeks to an elevation of almost 10,000 feet.

To the following persons the writer wishes to express his appreciation for their help with this study: my wife for her invaluable assistance both in the field and for her help with the manuscript; Dr. W. J. Hamilton, Jr. of the Department of Zoology of Cornell University for his many suggestions and correction of the manuscript; Dr. W. C. Muenscher of the Department of Botany of Cornell for his aid in the identification of food plants; Dr. R. Matheson and Dr. W. Middlekauf of the Department of Entomology of Cornell for their identification of ectoparasites; and to the owners of the Trinchera and Johnson ranches in Costilla County for permission to carry on field investigations on their respective properties.

In this area plant associations consisted of an *Artemisia-Chrysothamnus-Sarcobatus* complex on the floor of the valley, which gave way abruptly to a belt of piñon pines and junipers (*Pinus edulis* and *Juniperus monosperma*). Together these two associations have been designated as the Upper Sonoran Life Zone

(Cary, 1911). The so-called Transition Zone is best indicated in this region by the presence of yellow pines (*Pinus scopulorum*), but in the area studied the yellow pine association is quite irregular and does not form a definite belt above the piñon pines and junipers. White firs (*Abies concolor*), lodge pole pines (*Pinus murrayana*), and quaking aspen (*Populus tremuloides*) appear above the yellow pines and, together with the Engelmann spruce (*Picea engelmannii*), which is found mostly above 9,200 feet, indicate the presenee of the Canadian Zone.

Many factors such as slope exposure and gradient, warm air currents from the valley, and cold mountain streams have acted to cause irregularities in the plant associations. Thus, tongues of the *Artemisia-Chrysothamnus* association, characteristic of the valley floor, have extended up the stream valleys to 9,000 feet or more, which is well within the Canadian Zone.

It is along these tongues of Upper Sonoran vegetation that the prairie dogs have extended their range upward to the mountain meadows or parks that would otherwise be largely cut off from them by belts of timber, which are unfavorable as a habitat. In these meadows, the prairie dogs have found an excellent habitat with an abundant food supply. However, the shortened growing season at these higher altitudes is a detracting factor and probably limits their ascension to the vicinity of 10,000 feet, even though suitable meadow habitat extends much higher. In other areas, prairie dogs are known from slightly greater elevations, but in those cases some factor, such as a warm current of air, may cause the snow to melt earlier than it normally would at such an altitude.

In the present study, the Gunnison Prairie Dog (*Cynomys gunnisoni gunnisoni*) was selected for a number of reasons. In the first place, control operations have so reduced other species of prairie dogs, particularly the black-tailed form in the plains area, that sufficient concentrations for study are difficult to find. In fact, some observers have become alarmed over the prospect that if control measures are carried on as thoroughly as they have been in the past, certain forms of prairie dogs will be doomed to extinction (Alexander, 1932). Actually, the black-tailed prairie dogs have been so reduced in numbers on most sections of their range that they no longer present a serious menace to agriculture. In parts of their range, the mountain dwelling, white-tailed species still exists in numbers that approximate its former abundance.

One such area is the San Luis Valley of south central Colorado. There relatively little control has been exercised, especially along the eastern side, where prairie dogs are abundant wherever the habitat is suitable. As is characteristic of the white-tailed species, it is not limited to the flat land of the valley floor, but extends its range up into the higher meadows of the Sangre de Christo Mountains, which border the San Luis Valley on the east. This altitudinal distribution from the high meadows down to the floor of the valley at 8,000 feet was another reason for selecting the area for study, as the effect of the retarded summer season at higher altitudes on the reproductive cycle of the species was of especial interest.

The object of this investigation was to make an intensive study of the ecology

of the prairie dog in a limited area during the summer months. It was thought best to confine observations to a limited area because the habits of these animals are known to vary markedly in different ecological situations.

GENERAL HABITS

As nearly as could be determined, prairie dogs were strictly diurnal. Usually they came out of their burrows within fifteen minutes after sunrise, but as often as not spent a few moments merely enjoying the warmth of the first rays of the sun before commencing to feed. Feeding usually continued actively for about two hours when the adult animals, apparently having their fill for the time being, retired to their burrows or spent their time stretched out in the sun, dust bathing or grooming their fur. Young animals tended to feed more or less continually throughout the morning.

The middle of the day was a time of little activity; those dogs that remained above ground fed in a desultory manner. Toward late afternoon both young and adults foraged more actively again and by sundown all retired to their burrows. When feeding, prairie dogs spent one-fourth to one-half of their time watching for enemies. They searched for food on all fours for 5–10 seconds and then sat up on their haunches for 3–4 seconds, peering about for possible danger. If something caught their attention, they usually sat bolt upright or even stood on the tips of their toes. Occasionally one climbed to some vantage point on top of a clump of sage brush, rock, or tussock of grama grass for a better view.

Even though this species does not live in as closely knit towns as does the black-tailed species of the Great Plains, individuals are greatly dependent upon each other for warning in case of approaching danger. The moment one dog gave a shrill warning bark, every other prairie dog within hearing immediately sat up to locate the source of disturbance.

At times they showed a certain degree of territoriality; old males especially chased any that approached too near their burrows. A few moments later, however, the same males might be feeding peaceably alongside several others.

When observations were begun in late June, the adult males were already living somewhat apart from the rest and as the summer advanced this tendency was increased. Subadult or yearling males were not so solitary and usually lived in closer proximity to the females and young. Apparently the females weaned the young about three weeks after they first came above ground and soon afterward left them at the nest burrow and established themselves in another unoccupied burrow or dug a new one. Burnett and McCampbell (1926) state that the Zuni Prairie Dogs in western Colorado have similar habits. The young seemed to stay about the nest burrows for at least two to three weeks after the females left them and then gradually dispersed to nearby abandoned burrows where they took up residence. In no case was a young of the year observed digging a new burrow for itself, at least not one deep enough to live in.

On stormy days there was little or no activity and few dogs ventured from their burrows. Even a passing thunder shower sent most of them below ground, but as soon as the sky cleared, they reappeared.

BURROWING ACTIVITIES

There was a marked difference between the mountain dwelling *gunnisoni* and the black-tailed plains species (*Cynomys ludovicianus*), found but 20 miles to the eastward. While the mountain animals were in some respects colonial, there was not the obvious gregariousness shown by *ludovicianus*. Most of the so-called colonies or towns that I encountered in Costilla County were merely aggregations of burrows on especially favorable sites. Fully as many burrows were isolated as were found in groups. In the mountains, the favorite burrowing site was on sloping ground above the edges of meadows. Few burrows were dug in the meadows themselves because of sub-surface water. While there appeared to be a definite preference for open ground, it was not uncommon to find burrows scattered throughout the sage brush and even in groves of aspen. In the valley, abandoned cultivated land harbored the greatest concentrations of burrows. Moreover, these white-tailed animals did not show a definite tendency to clear all vegetation from about the mouths of their burrows to obtain an unobstructed view as has often been reported for *C. ludovicianus*, (Merriam, 1901, Seton, 1937) (see plate 1).

Another striking difference between the two species was the type of mound built about the entrances to their burrows. On the plains, prairie dogs usually construct and carefully maintain crater-shaped mounds several inches high for the purpose of keeping surface water from entering their burrows (Merriam, 1901). These are reportedly built up both from the dirt dug out of the burrows and from dirt collected on the surface and they are packed firmly by repeated blows of the prairie dogs' noses.

The Gunnison prairie dog constructs mounds, but they are seldom large; they are built entirely from dirt dug out of the burrow and no attempt at packing them was ever observed. In the mountains, there appeared to be a definite correlation between the size of the mounds and the steepness of the slope on which they were located. In other words, on steeper slopes there is better runoff of excess surface water and therefore large mounds were seldom constructed. In fact, many times there was no attempt to build a circular mound and the excavated earth was merely kicked out in a pile on the downhill side after the manner of a ground squirrel. On the whole, the prairie dogs living on the flat land of the valley floor built larger mounds than those in the mountains. It should be noted, however, that mounds were usually added to and enlarged at burrows that were occupied for more than one season. This was evidence that the burrows were being continually excavated and repaired while they were occupied. The only method observed by which prairie dogs removed dirt from the burrows was for them to scratch it out with their hind feet. A young prairie dog kept in captivity for two weeks likewise never showed any inclination to push dirt out with its fore feet or to bring out armloads of dirt. Its method of digging was to loosen the dirt with its front feet and then to push it behind with several vigorous kicks of its hind feet used in unison.

The excavations of four burrows are shown in figures 1, 2, 3, and 4. A few facts should be noted concerning them. Figure 1 shows a typical burrow in a

mountain meadow, which had been inhabited for more than one season. It was in close proximity to several others and there were connecting passages between them. A prairie dog living in this type of colony will, when frightened, run into the nearest hole as it can easily reach its own burrow through one of the connecting underground passages. However, a prairie dog that lives in a more isolated burrow not connected with others nearby will dash past the entrances of the others in an effort to reach its own.

Recently dug burrows, that is those that had been started a month or two previous to observation, were usually shallow, were not very elaborate, and did not contain nests (fig. 2). It appeared that if these burrows were occupied for more than one season, they were subsequently enlarged throughout the summer

PLATE 1

A burrow entrance of Gunnison prairie dog at 9,500 feet. Little effort has been made to clear away vegetation.

and the shallow tunnels dug the first season were often plugged with earth from deeper excavations. This process, along with normal erosion, might account in many cases for the rather small mounds at the entrances of deep, extensive burrows. The size of the mound was observed to be a variable indicator of the extent of the burrow.

It has been stated by Seton (1937) that these animals will vacate and plug a burrow in which a dead member of their kind is located. To check the validity of this statement, a number of burrows were marked into which prairie dogs that had been badly wounded with a .22 caliber rifle had escaped. In no case was one of these burrows plugged or even vacated, and they continued to be inhabited as long as they were under observation. To check this behavior still further,

several dead dogs were placed in various burrows. The results were the same. More conclusive proof was obtained when a burrow was excavated into which a wounded animal had escaped some two weeks previously. When the burrow

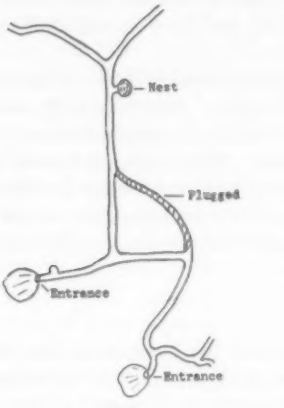

Fig. 1

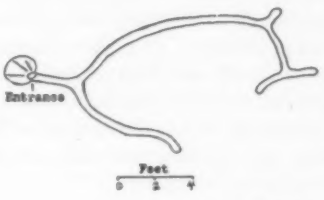

Fig. 2

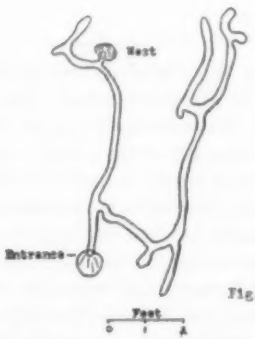

Fig. 3

Fig. 4

FIG. 1. A typical mountain meadow burrow in close proximity to several others. Note connecting passages. Average depth 4 feet 7 inches. FIG. 2. A recently dug burrow in a mountain meadow. Note its simplicity. Average depth 2 feet 9 inches. FIG. 3. A shallow burrow in a boggy mountain meadow. Average depth 2 feet 5 inches. FIG. 4. An extensive burrow on the floor of the San Luis Valley. Average depth 6 feet 8 inches.

was opened, an immature female was found to be inhabiting it and the decayed carcass of the one that had been wounded was found in a side passage (fig. 4).

Nest material was generally collected from the nearest available source. The nest found in the burrow excavated at 9,200 feet (fig. 3) was composed entirely of dry grass, completely filling the almost circular nest cavity, which was nearly eight inches in diameter. The nest of the burrow excavated in the valley (fig. 4)

was composed of the dry stalks of false mallow (*Sphaeralcea coccineum*), which had been somewhat chewed. This plant was the most abundant one in the immediate vicinity and also served as an important source of food. At the bottom of the latter nest was considerable dirt mixed with the plant stalks that were partly decayed, showing that fresh material had been subsequently added to the top.

Throughout the latter part of July and in August several individuals were noted carrying bundles of nesting material in their mouths. On August 29, one was observed in this act. It gathered as many dry stalks of *Sphaeralcea* as it could hold in its mouth and then retired to its burrow. Three minutes later it again appeared, gathered another bundle, and was about to re-enter when I collected it with the bundle still in its mouth. The animal was an immature female that evidently had recently acquired an abandoned burrow for herself and was furnishing it for the winter.

SANITATION

For the most part, droppings were found about the mounds or dust baths. Some were dropped where the animals had been feeding and a few were likewise found in the underground passages. None was observed in any of the nests excavated. There was certainly no place to which the animals regularly retired to defecate.

REPRODUCTION

As this study was begun in late June, the young were already above ground in the valley and new litters appeared almost daily at higher altitudes. The lateness of the season in the mountains so retarded the reproductive cycle of the prairie dogs that there was a graded series of development of the young from the valley floor to the high meadows. This was probably closely correlated with the melting of the snow and subsequent emergence of the adults from hibernation to start the breeding season. Since work was begun too late to check the first dates of pregnancies and births, the best indication available to check the stage of the reproductive cycle was the date when the young first appeared above ground. In this respect the following dates were recorded: June 27—8,500 feet; July 1—8,800 feet; July 14—9,200 feet; July 16—9,500 feet. Stockard (1929b) who studied *C. leucurus* placed the gestation period at 27–33 days and decided that the young remained in the burrow for about three weeks before coming above ground. I see no reason to suspect that *C. gunnisoni* differs much from this schedule.

Numbers of young in litters were determined by uterine scar counts. This appeared to be, in the case of the prairie dogs, an excellent method for determining the size of litters as these scars of placental attachments were clearly visible in September in females that had borne young the previous May. Uterine scar counts, however, may not give an entirely true picture for in the event that embryos were resorbed there might be some indication of a scar although less distinct than a normal one. Likewise scar counts do not indicate the actual

numbers of young raised to maturity, but they are certainly as useful as embryo counts in determining the reproductive capacity of the prairie dog.

According to scar counts, the average number of young per litter for 55 females was 3.9. When the females were separated into age groups on the basis of tooth wear and weight, those of one year and those of two years or older, however, it was found that the yearling females averaged 2.4 young each. Out of 35 adult females only one was barren, whereas 8 out of 20 subadult or yearling females failed to produce young. Considering only those females that produced young, the sub-adults averaged fewer than the adults—4.1 to 4.9. Stockard (1929b) gave the average number of young for *C. leucurus* as 5.4, but he did not divide them into age groups. He also gave the maximum number of embryos he observed in one female as 10. The largest number of uterine scars found in *gunnisoni* was 8. Likewise, Aldous (1935) noted that 27 females of *C. g. zuniensis*, of which he did not specify the age, averaged 4.8 young each on the basis of embryo counts. Hamilton (1934) found a similar situation prevailing with the eastern woodchuck, *Marmota monax rufescens*, in that sub-adult females averaged fewer young than the adults.

Lactating females were taken in the valley until July 23, which indicates that the young were nursed nearly three weeks after coming above ground. Stomach contents of young, on the other hand, showed that they took very little milk and were almost entirely independent of their mothers after they had been above ground for about a week. On several occasions females were observed nursing young. In each instance the female sat almost upright on her haunches while the young crowded about her. Some nursed from the pectoral and others from the inguinal mammae. All females examined of this race had five pairs of mammae, two pectoral and three inguinal.

GROWTH

The development of the young was traced by collecting and weighing numerous individuals from the same localities throughout the summer. While this method was somewhat inaccurate because of the slight variance in age among the young in any given locality, the general rate of growth could be determined. Since an individual might eat as much as 60 to 70 grams of food in a day, it was necessary to compensate for this as much as possible by subtracting the weight of the stomach contents from the total weight. In this way, a vital weight was derived, which gave a more accurate record. As the young at higher altitudes were born later in the season, the area studied was divided into three different levels—the valley, the foothills, and the mountains—in order to group the young of similar ages together. Likewise, it was found that males usually averaged heavier than females of like age, so the sexes were considered separately.

The following tabulation compares the weights of average young from the three different levels on as nearly comparable dates as possible. It should be noted that the rate of growth in the foothills was higher than in the valley and that the rate was still higher in the mountains. This might be explained on the basis that there was a greater abundance of green feed at higher levels. At any rate, it

shows how the prairie dogs have adapted themselves to take advantage of the shorter growing season prevailing in the higher parts of their range.

Immature males

DATE	VALLEY (7,600–8,300 FT.)	FOOTHILLS (8,300–8,700 FT.)	MOUNTAINS (8,700–9,500 FT.)
July 12	342 grams	294 grams	—
" 16	—	—	152 grams
Sept. 2	—	548	556
" 4	646	—	—

Immature females

July 12	314	298	177
Sept. 2	—	—	518
" 4	536	531	—

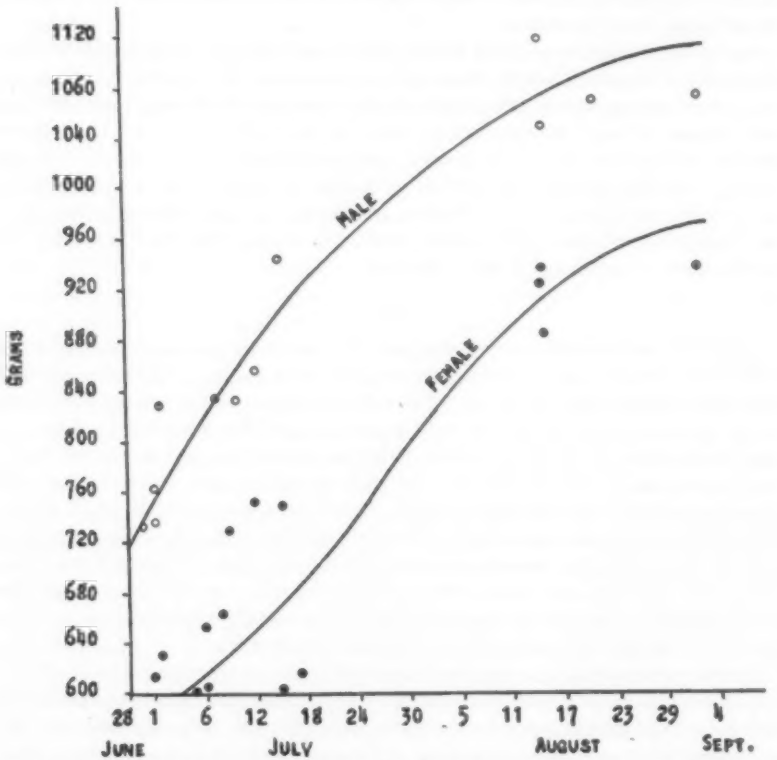

FIG. 5. The relative increase in weight of adult males and females through the summer in the high foothills and mountains (8,500–9,500 feet).

A young male captured at 9,500 feet on his second day above ground, July 17, was kept in captivity for 15 days. In this time he gained 83 grams on a diet of condensed milk, oats, and heads of blue grass.

Differences in weight between adults and sub-adults or yearlings were likewise of interest. Considering specimens from the same general localities, collected on the same dates, it was found that adult males averaged slightly more than 300 grams heavier throughout the summer than did sub-adults. On the other hand, it was found that, considering females on the same basis, adults averaged slightly less than 100 grams heavier than sub-adults. The smaller amount of difference between the two classes of females might be attributed to the fact that sub-adult females averaged fewer young and more of them were barren. The adult females, carrying a greater burden of nursing young, were prevented from storing fat as rapidly as the sub-adults.

Figure 5 indicates the increase in weight of adult males and females through the summer in the high foothills and mountains (8,500–9,500 feet). This increase represents the storage of fat toward hibernation in the autumn. On the whole, males averaged heavier than females through the summer, but the total gain in weight for both sexes was about equal.

FOOD HABITS

The following tabulation gives the percent frequency of occurrence of food items in 157 stomachs:

FAMILY	PERCENT	PRINCIPAL KINDS EATEN
Graminae	81.4	*Poa, Sporobolus, Agropyron*
Boraginaceae	26.3	*Cryptanthe*
Chenopodiaceae	26.3	*Salsola, Chenopodium*
Cruciferae	19.2	*Descurainia*
Compositae	17.9	*Taraxacum, Verbesinia*
Leguminosae	14.1	*Lupinus, Melilotis, Trifolium*
Malvaceae	11.5	*Sphaeralzea*
Solanaceae	8.3	*Solanum*
Polygonaceae	6.4	*Polygonum*
Amaranthaceae	1.3	*Amaranthus*
Scrophulariaceae	0.6	*Collinsia*
Unidentified vegetation	10.2	Dicotyledons
Insect	10.2	Coleoptera, Lepidoptera

Since no significant difference was found in the food of young and adults, all of the stomach contents were considered together. Several observers have stated that prairie dogs have few food preferences and will take almost any green vegetation available. Taylor and Loftfield (1924), however, showed that in northern Arizona the Zuni prairie dogs had a decided preference for certain species of grass. In addition to showing preferences for a limited number of plants, the stomachs examined in this study demonstrated that usually only the heads or inflorescences of some plants were taken. This was the case with *Poa pratensis*, *Sporobolus cryptandrus*, *Sphaeralcea coccineum*, and *Descurainia sophia*.

The above tabulation, which is calculated in percent frequency of occurrence of food items, does not give an accurate picture of the relative bulk of each food item. It is almost impossible to calculate the percentage by bulk of the various foods in a prairie dog's stomach because of the thorough trituration which they undergo.

Certain items of the insect food were in all probability picked up by accident with the plants the prairie dogs ate, but for the most part the individual insects were too large to have been taken in this manner. Insects are not uncommonly taken by prairie dogs. Burnett and McCampbell (1926) in their study of the Zuni prairie dog in Montezuma County, Colorado, record beetles and numerous cutworms among the various food items taken. Smith (1915) and Stockard (1929a) found prairie dogs eating large numbers of grasshoppers, actually jumping into the air to catch them as they flew by. Likewise Kelso (1939) in his comprehensive study of the food habits of prairie dogs lists cutworms and grasshoppers among their food.

Although prairie dogs have fairly well developed cheek pouches, over one half inch long, they were never observed to use them to carry food material. Occasionally a residue of the plant material that had been most recently eaten was found lodged in the pouches, but at most this consisted of a leaf or two or possibly a few spikelets of some grass. Probably the best evidence in this regard is that to the writer's knowledge no food stores have ever been found in prairie dogs' burrows. Where prairie dogs range into areas that have winters so severe that they are forced to hibernate, they apparently depend solely upon the fat stored during the preceding summer to tide them over.

ENEMIES

Buteo hawks, coyotes, and badgers were found to be the principal enemies of prairie dogs in this area through the summer. Weasels were abundant and although two were seen entering prairie dog holes, there was no evidence that they preyed upon the inhabitants to any great extent. Black-footed ferrets were exceedingly rare as was shown by the fact that an old man who had lived on a ranch in the San Luis Valley for 38 years said that he had seen only four in that time. The ferrets that do occur probably account for their share of prairie dogs as they are known to feed extensively on them in the plains area (Merriam, 1901). Almost 100 burrowing owl pellets were collected in the valley, but none contained any remains of prairie dogs. The owls always inhabited abandoned burrows, although they were often within a few feet of burrows that were occupied by prairie dogs.

Of six ferruginous rough-legged hawks examined, four had remains of prairie dogs in their stomachs. Likewise, two out of three red-tailed hawks had fed on prairie dogs. Two other red-tailed hawks and two golden eagles were seen to make unsuccessful attempts to catch them.

Coyotes hunted prairie dogs chiefly in the valley and stayed out on the flats well into the morning obviously hunting for them. Fifteen coyotes were seen during the summer and twelve of them were definitely hunting prairie dogs on the flats. On August 7, a female was seen carrying a prairie dog to her three

pups a short distance away. Two of the pups were collected and each contained parts of a prairie dog in its stomach, indicating that the female had made more than one successful catch during the morning. Two other adult male coyotes were also collected; one had two prairie dogs in its stomach and the other contained one. No other food items were found in any of their stomachs. At least two of the prairie dogs that had been captured were adults as determined by the wear on their cheek teeth, the size of their hind feet, and the moult on their hind legs (young of the year still retained the soft, fluffy juvenal pelage on their hind quarters). This shows that the inexperienced young were not the only ones captured by the coyotes.

In a mountain meadow at 9,500 feet, a female badger dug out 14 prairie dog burrows in 6 days during the early part of July. This amount of activity might have been slightly greater than normal as she was followed by two almost half grown young at the time. Several other burrows were excavated for a distance of a few inches and then abandoned, possibly because they were not then inhabited.

Much has been written concerning the relationships of prairie dogs, burrowing owls and rattle snakes. The early literature contained accounts of their amicable association, but more recently it has been claimed that prairie dogs will entomb a rattle snake if they find it in their burrow (Seton, 1937). In an effort to get at the truth of this relationship, four rattle snakes (*Crotalus viridens*) were kept, tethered by cords tied to their tails, in the burrows of prairie dogs for an average period of four days each. In no case was there any indication of the dogs attempting to bury the snakes. Throughout the day the snakes generally remained in the burrows, but at night they came out and usually crawled away to the length of the cord. As nearly as could be determined the prairie dogs remained in the burrow as long as the snake blocked the exit, but when the snake left they deserted the burrow and did not return for several days after the snake was removed. Even in burrows with two entrances they did not attempt to bury the snake. On two occasions rattlers were discovered seeking refuge during the day in prairie dog burrows, but in each instance these were abandoned burrows.

PARASITES AND DISEASES

Although plague has been reported among prairie dogs in New Mexico (Gabrielson, 1939), none was evident in Costilla County. The only ectoparasites inhabiting the prairie dogs in this locality were fleas belonging to the genus *Opisocrostis*. Burnett and McCampbell (1926) reported that the prairie dogs there were infested with fleas, ticks (*Ixodes sculptus* and *Ixodes kingi*), and *Cuterebra* larvae.

ECONOMIC IMPORTANCE

There can be little doubt that in the area studied prairie dogs definitely conflicted with the best interests of livestock on the range land and to some extent with cultivated crops. Since over 80 percent by frequency of occurrence of their food was composed of species of grass especially useful to cattle and sheep and only about 16 percent consisted of plants such as the Russian thistle, *Salsola kali*, and the nightshade, *Solanum nigrum*, which are distinctly undesirable pests on

the range, the presence of the prairie dog is not favorable. A few dogs invaded hay fields, but as a rule this land was too wet for their successful colonization. In the valley, most of the prairie dogs lived in abandoned fields or on wild land where there was little brush.

It is apparent that in the valley clearing of the land for agriculture has favored the increase of prairie dogs. On wild land where sage brush was over a foot high, prairie dogs did not average more than one or two per acre, but where the brush had been cleared or where natural openings occurred the average was considerably higher and might on certain fields have reached 15 to 20 per acre. Extreme concentrations ran as high as 30 per acre. Further evidence of this preference for open land in the valley was the concentration of prairie dogs along the cleared rights-of-way beside highways and railroads. They became indifferent to passing cars and a considerable number were killed as they crossed the road.

Burrows are often injurious to stock, particularly horses, which step in them while running. One rider was killed in this locality in 1940 when his mount stepped into a prairie dog hole, which had been enlarged by a badger, and threw him against a rock.

In spite of the fact that the prairie dog is one of the most characteristic and interesting animals of the West, it is evident that on most parts of its range it should be rigidly controlled, not necessarily to the point of extinction, but sufficiently so that it is no longer detrimental to agriculture and the livestock industry.

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THE STATUS OF THE WOLF IN MICHIGAN

By A. M. Stebler

During recent years there has been considerable interest shown by some persons toward the welfare of the wolf (*Canis lycaon*) in the Great Lakes region. There is a feeling, and a justifiable one, that this species is well on the way toward extirpation in this region. Control systems, particularly of the bounty type, have commonly been held to be largely to blame for this situation. Other adverse factors usually are not considered or are vaguely understood. However, it is apparent in Michigan that changes wrought in the wolf's habitat have probably reduced the population more severely than any other form of human influence.

DISTRIBUTION

Originally the wolf was such a wide-ranging species (Anthony, 1928, p. 254; and Seton, 1929, p. 256) as to leave little doubt that it once occurred throughout what is now known as Michigan. This belief is supported by Dice (1927, p. 39) who expresses the opinion that it "occurred originally over all of Michigan. . . ."

In 1838 bounties were paid on wolves from Lapeer County (Mich. Sen. Doc., 1839, p. 128) and this seems to be the earliest official record attesting the occurrence of this species in Michigan. Ten additional counties, Branch, Cass, Genessee, Ingham, Jackson, Kalamazoo, Kent, Macomb, St. Clair, and Van Buren, presented wolves for bounty payments in 1839 (State of Mich., Jour. of Sen., 1840, vol. 1, p. 101). To be sure, it is possible that some of the animals submitted as wolves may have been coyotes, but at the same time, it is likely that wolves were then more prevalent through this area than coyotes. Later, Wood (1914, p. 8) published records indicating a wide distribution (fig. 1) for the wolf in Michigan. Especially interesting today is the broad former distribution he indicates for the species in the southern part of the Lower Peninsula.

In marked contrast to this picture of past wolf distribution is that of the present (fig. 1). This species has now been entirely extirpated from the southern one-third of Michigan. Occurrence records, available as a result of bounty disbursements from January 1935 to December 1941 inclusive, indicate that the range of the wolf is practically, if not entirely, restricted to the Upper Peninsula. Specimens presented from six counties in the Lower Peninsula, namely: Cheboygan, Crawford, Kalkaska, Oscoda, Otsego, and Roscommon have been recorded as wolves in the departmental files, but the correct identity of none of these has been verified.

Even though the range of the wolf may now be confined to the Upper Peninsula, it is not improbable that during the winter occasional individuals cross the Straits of Mackinac on the ice to the northern part of the Lower Peninsula. Because of the apparent preference shown by Michigan wolves for areas of relative wilderness, this species is not likely to become re-established in this region.

HABITAT

The wolf in Michigan seems definitely to prefer areas where conditions of relative wilderness prevail and in which human habitations are scarce or absent. Close proximity to civilization seems always to be avoided. With the destruc-

FIG. 1. The distribution of the wolf in Michigan

tion of the wilderness resulting from logging operations, and the subsequent spread of civilization, the wolf has been forced to abandon much of its former range in this state, persisting only in the few remaining larger wilderness areas.

Thus, it appears that the modification of the primitive habitat by man may

have had more effect in reducing wolf range and numbers in Michigan than all the control measures that have been attempted.

NUMBERS

It is difficult, of course, to estimate Michigan's wolf population, but bounty records indicate that the species is not abundant in the sense that deer are. Where the annual take of wolves for bounty payments has averaged but 33 in-

TABLE 1.—*Wolves turned in for bounty payments in Michigan*

COUNTY	1935	1936	1937	1938	1939	1940	1941	TOTAL	AVERAGE
Upper Peninsula:									
Alger	9	3	1	6	1	0	0	20	2.86
Baraga	1	1	1	4	1	0	0	8	1.14
Chippewa	5	0	9	9	13	9	8	53	7.57
Delta	0	1	1	0	2	6	0	10	1.43
Dickinson	4	1	1	0	1	0	3	10	1.43
Gogebic	0	0	2	7	0	3	9	21	3.00
Houghton	1	1	0	0	0	0	0	2	0.29
Iron	2	2	4	3	1	1	2	15	2.14
Keweenaw	1	0	0	0	0	0	0	1	0.14
Luce	0	0	8	10	14	6	13	51	7.28
Mackinac	0	1	0	0	0	0	0	1	0.14
Marquette	3	0	1	2	1	0	0	7	1.00
Menominee	2	1	0	0	0	0	0	3	0.43
Ontonagon	1	3	2	0	0	0	3	9	1.28
Schoolcraft	1	1	4	1	1	4	4	16	2.28
Total	30	15	34	42	35	29	42	227	32.43
Lower Peninsula:									
Cheboygan	0	0	1	0	0	0	0	1	0.14
Crawford	0	1	0	0	0	0	0	1	0.14
Jackson	0	0	0	1	0	0	0	1	0.14
Kalkaska	0	0	1	0	0	0	0	1	0.14
Oscoda	0	0	0	1	0	0	0	1	0.14
Otsego	0	0	0	0	0	1	0	1	0.14
Roscommon	0	1	0	0	0	0	0	1	0.14
Total	0	2	2	2	0	1	0	7	1.00
Total for State	30	17	36	44	35	30	42	234	33.43

dividuals per year during the past seven years (Table 1), the number of deer killed during the open season is estimated to average 40,000 individuals per year (Mich. Dept. Cons., 10th Bien. Rept., Game Div. Sep. p. 50).

The home range of one family of wolves (fig. 2) studied in winter on the Cusino Game Area, is estimated to extend over approximately 260 square miles. This family consisted of a pair of adult wolves and two young, which gives a population of one *adult* wolf to 130 square miles. If this population density prevails over

the Michigan wolf range generally, wolves can hardly be considered "numerous" or "abundant."

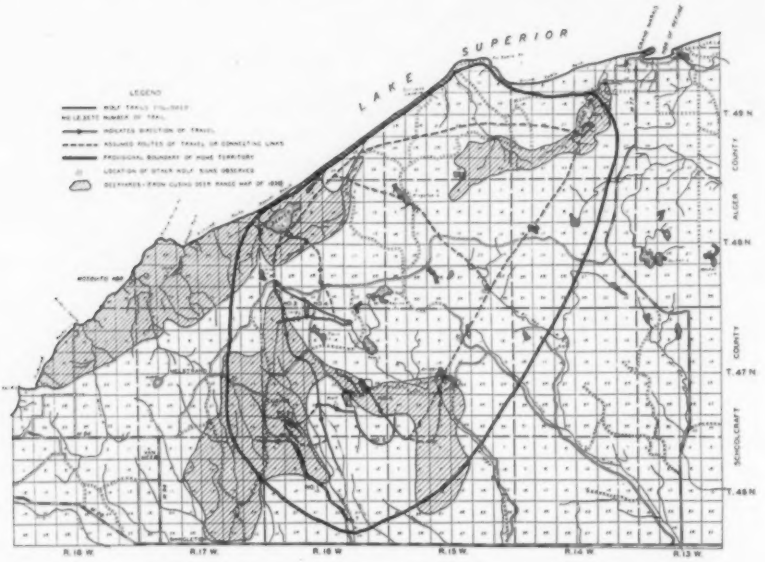

FIG. 2. Map showing the home range of the wolves at Cusino

TABLE 2.—*Classified list of food items found in 8 wolf stomachs, one of which was empty*

GROUPS AND SPECIES	MAY		JUNE		JULY		DECEMBER		TOTAL TIMES OCCURRED		PER CENT OCCURRENCE	
	Carrion	Non-carrion	Carrion	Non-carrion	Carrion	Non-carrion	Carrion	Non-carrion	Carrion	Non-carrion	Carrion	Non-carrion
Mammals	1	2				1		1	1	4	14.3	57.1
Rabbit (unidentified further)		1						1		2		28.5
Deer	1	1	1			1			2	2	28.5	28.5
Insects						1				1		14.3
Grasshopper						1				1		14.3
Miscellaneous		1				2		1		4		57.1
Debris		1				2		1		4		57.1

HUNTING AND FEEDING HABITS

The hunting and feeding habits of the wolf in Michigan remain relatively unknown. According to stomach and scat analyses of the meager material collected during only a few months of the year (Tables 2 and 3), deer and snowshoe

hares are equally important in the diet of the wolf. Field observations, on the other hand, indicate that in winter deer form the dietary main-stay of this carnivore. However, when the scarcity of wolves is considered in comparison with the high deer population, and with the numbers of deer lost as a result of winter mortality factors other than predation, wolf depredations are relatively insignificant.

It is interesting to note that in July one wolf stomach contained the remains of at least three grasshoppers, and that one scat taken in March contained crayfish remains.

TABLE 3.—*Classified list of food items found in 8 wolf scats*

	JAN.	FEB.	MAR.	TIMES OCCURRED	PER CENT OCCURRENCE
	Number of scats				
	4	1	3		
Mammals	4		3	7	87.5
Meadow mice			1	1	12.5
Snowshoe hare	1		2	3	37.5
Deer	2		1	3	37.5
Unidentified	1				12.5
Crayfish			1	1	12.5
Grass		1		1	12.5
Miscellaneous	1			1	12.5
Debris (mud)	1			1	12.5

ON TRIAL

The charge most frequently hurled against the wolf in Michigan is the traditional one, namely, that this species is an extravagant predator. Whereas formerly accusing fingers were pointed at the wolf because of its actual or alleged destruction of domestic livestock, today it is condemned because it is believed to prey excessively upon deer. While it may be true that wolves do kill relatively more deer than some other predators, it needs to be pointed out that the majority of deer are killed (aside from legal hunting) by agencies other than predation.

From 1932 to 1939 inclusive, 238 deer carcasses were autopsied to determine the probable causes of death (Table 4). Most of these deer carcasses were found in the winter and early spring when wolf predation is commonly believed to be at its height. A few of the carcasses were found in the late fall, but the table contains the records of none collected during the summer. Predation was judged the immediate cause of death in 13 per cent of the cases, whereas other causes, such as malnutrition, disease, and accidents, were judged to be the cause of death in 72 per cent of the cases. Unknown causes accounted for 15 per cent of the deaths. If the summer toll of deer along the State's highways were available and added to these data, without doubt predation would become even more minor as a deer mortality factor.

Considered from a long range viewpoint, predation is not necessarily a harmful influence upon prey species. The works of Errington and Hamerstrom (1936), Murie (1935), and others, as well as the results of these investigations, which are only briefly reported here, show plainly that it is possible for both predator and prey species to live together without apparent disadvantage to either. Likewise, they show that predatory species do not impose a relentless or fatal drain upon prey species.

In Michigan, the wolf and other predators have not prevented the State's deer herd from increasing. The fact that during the last decade or two deer have become so numerous in many areas as to be faced with an inadequate supply of winter forage annually (Bartlett, 1938) shows clearly that the numerical increase of the deer has not been materially hampered by predation.

TABLE 4.—*Deer mortality and its apparent causes*[1]

APPARENT CAUSE OF DEATH	ADULT MALE	ADULT FEMALE	IMMATURE MALE	IMMATURE FEMALE	AGE AND SEX UNCERTAIN	TOTAL	PERCENT
Complex {Malnutrition, Parasitism, Disease}	0	1	25	19	0	45	19
Malnutrition	1	3	26	9	1	40	17
Parasitism and Disease	0	12	12	14	1	39	16
Unknown	2	4	4	1	24	35	15
Predation (Includes 5 cases of known dog kills)	0	4	4	7	16	31	13
Accident (Collision with vehicles, fences, etc.)	1	13	5	7	3	29	12
Gunshot	6	2	4	5	2	19	8
Total	10	39	80	62	47	238	
Percent	4	16	34	26	20		100

[1] Based upon data accumulated by the Game Division's staff from 1932 to 1939 inclusive, but most of which was furnished by S. C. Whitlock of the Game Division Laboratory, Michigan State College, East Lansing.

WHITHER THE WOLF IN MICHIGAN?

With the advent of Europeans into Michigan and the modifications of the primitive habitat for which they were responsible, the range of the wolf has shrunk until it now is restricted to the Upper Peninsula. Even here the wolf's distribution is not general, but rather it seems confined to the wilder and more remote districts. With the number and the size of these districts tending to diminish with the passage of time, the wolf is in real danger of becoming entirely extirpated in Michigan.

The loss of so spectacular and notorious a member of the State's native fauna would be unfortunate, to say the least. Knowledge of the mere occurrence of wolves imparts to a district a wilderness charm otherwise lacking. To forestall,

or prevent, the passing of the wolf in Michigan, or for that matter, in the Great Lakes' region generally, what measures can be taken?

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DISTRIBUTION AND STATUS OF PRONGHORN ANTELOPE IN MONTANA

BY JAMES BEER

The survey of pronghorn antelope in Montana was part of the general game survey facilitated by the Pittman-Robertson Program. The actual work was carried on by three field crews of two men each who spent their entire time during the summer of 1941 on the prairies of Montana.

The figures in this report are based upon observation by the field parties, reports by deputy wardens, and the testimony of the local ranchers and sportsmen.

BRIEF HISTORY

When white man first came to the plains of Montana, he found them teeming with big game species. The pronghorn equaled or even surpassed the buffalo in numbers. Seton estimates that there were originally about 40,000,000 pronghorns in North America. Based in proportion to the total range, there must have been originally about 2,500,000 head in Montana alone. As late as 1896 (Seton) as many as 40,000 head were known to winter in the breaks and coulees of the Milk River alone.

When the semi-arid plains that are the home of these animals were opened up to homesteading, the settlers nearly wiped out the once great bands of pronghorns.

By about 1922 (Nelson) there were but 3,000 head left in Montana. This remnant barely held its own during the twenties and early thirties but with the coming of the draught they began to increase. The effect of the draught was indirect in that millions of acres of land were abandoned by the farmers, thus enlarging their range. There was a gradual increase in the population until 1937 when it was estimated that there were about 10,000 head. After 1937 the range conditions improved greatly and the pronghorn increased rapidly in most areas.

TABLE 1.—*Pronghorn antelope populations in Montana*

YEAR	NUMBER	REFERENCE
Originally	2,500,000	Seton—Lives of Game Animals
1922–24	3,027	Seton—Lives of Game Animals
1937	10,602	Big-game inventory of the U. S. 1937
1938[1]	6,740	Big-game inventory of the U. S. 1938
1939[1]	7,142	Big-game inventory of the U. S. 1939
1941	14,233	(Table 2)

[1] The reports for 1938 and 1939 are probably much too low when checked against the present survey while the 1937 report was very accurate.

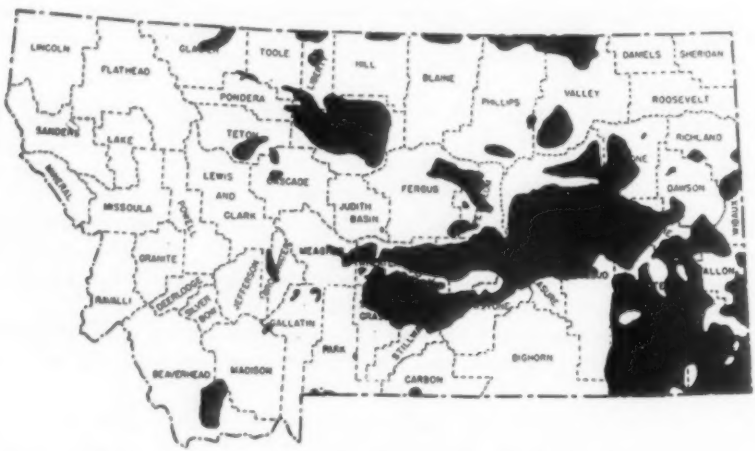

FIG. 1. Distribution of pronghorned antelope in Montana

The present habitat is not the fertile plains that their ancestors roamed but the rough breaks and gumbo flats that are not suitable for cultivation. This type of country is also their only protection from man and his automobile.

THE PRESENT POPULATION

There are roughly four main ranges for pronghorns in Montana. These are the Southeastern Range, the Central Range, Chouteau Range and the Northern

Range. There are other small bands not taken in by these ranges, but their numbers are small.

The Southeastern Range, for the most part is found in Custer, Fallon, Carter and Powder River counties, has the largest number. The largest herd is found in Carter County (see Table 2). The figures given for this area include only those

TABLE 2.—*Pronghorn antelope distribution in Montana, 1941*

COUNTY	NUMBER	COUNTY	NUMBER
Beaverhead	500	Mineral	—
Bighorn	—	Missoula	—
Blaine	80	Musselshell	600
Broadwater	250	Park	11
Carbon	22	Petroleum	475
Carter	2,500	Phillips	200
Cascade	75	Pondera	55
Chouteau	1,200	Powder River	1,000
Custer	500	Powell	—
Daniels	10	Prairie	270
Dawson	100	Ravalli	—
Deer Lodge	—	Richland	20
Fallon	200	Roosevelt	—
Fergus	150	Rosebud	350
Flathead	—	Sanders	—
Gallatin	45	Sheridan	5
Garfield	600	Silver Bow	—
Glacier	30	Stillwater	1,700
Golden Valley	550	Sweetgrass	200
Granite	—	Teton	150
Hill	425	Toole	170
Jefferson	—	Treasure	75
Judith Basin	5	Wheatland	500
Lake	—	Wibaux	50
Lewis & Clark	—	Valley	365
Liberty	150	Yellowstone	250
Lincoln	—		
McCone	300		
Madison	50		
Meagher	50		
Total			14,233

animals that are resident in the area and not bands that come in from South Dakota to winter.

The Central Range includes the large area between Dawson and Meagher counties. This area is generally populated, with the heaviest concentration in northern Stillwater County.

The Chouteau Range is relatively small, but due to the fact that it is rather isolated, it is treated by itself. There is a large population of animals in this range in proportion to its area.

The Northern Range is different from the others in that it has to deal with large numbers of transient animals. Most of these animals drift back and forth across the Canadian border. The figures given for this area are considered to be average.

There are bands scattered over much of eastern Montana. Some of them do not seem to fall into any of the range divisions given. The map of distribution, population tables, and general discussion give the main points of information on them.

MIGRATION AND MOVEMENTS

For the most part the seasonal movements of the pronghorn are not great. Most of the bands leave the flat unbroken prairie for an area of breaks or hills when the first bad weather comes in the fall. This movement is usually limited to but a few miles.

Along the Canadian border, in southern Park County and on the eastern border of Carter County there is a winter influx. The Canadian animals drift over the border with the winter storms and do not return to their home range until spring. These bands are reported to be quite large.

In Park County, some pronghorn migrate from the higher range in Yellowstone Park in the late fall. There are also a few permanent residents in this area.

It is only in severe winters that there is much movement of pronghorns in Carter County. During such winters, bands drift in from South Dakota to the protection of the breaks and buttes along the Little Missouri River.

Due to the location of winter ranges, there is little or no movement from Montana to other areas during the fall or winter. The shifting from summer to winter ranges and from winter to summer ranges is not a mass movement nor is it complete. The movement is merely a shifting of some of the bands and any particular area that is within the range, as shown in figure 1, has antelope throughout the year.

SUMMARY

Pronghorns are still found over much of their original range in Montana. While their numbers will never again approach the 2,500,000 head that originally roamed the prairies of Montana, they are increasing to a point where they may soon be numerous enough for an open season.

It is estimated that there are about 14,233 head in Montana at the present time.

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FURTHER DATA ON THE BLACK-TAILED PRAIRIE-DOG IN WESTERN CANADA

By J. Dewey Soper

The first, authentic information on the black-tailed prairie-dog (*Cynomys ludovicianus ludovicianus*) in Canada was gathered by the writer a few miles northwest of Val Marie, Saskatchewan, in late August, 1927. This involved a small colony that has since been obliterated by the construction of a reservoir on the Frenchman River. In early July, 1937, a large colony was located and studied in the Frenchman River Valley at a place locally known as "Prairie-dog Buttes", approximately 7.5 miles southeast of Val Marie. A full account of the species in Canada, as then known, was published by the writer (Jour. Mamm. vol. 19, no. 3, pp. 290–300).

Since then, additional information of interest has come to hand. In the summer of 1941, the first opportunity came to examine the Frenchman River Valley for some distance immediately north of the International Boundary. I had felt for many years that such an inquiry would unearth further evidence of the occurrence of *Cynomys* in Saskatchewan. It seemed particularly desirable to follow up an old report concerning the presence of a prairie-dog town in the Frenchman Valley between Breed and Otter creeks—a point about five miles north of Montana (Soper, *loc. cit.* p. 293). Investigations were carried out along about ten miles of the valley, north of the 49th parallel, from June 15 to 18, 1941. Results proved to be much more fruitful than anticipated. Not only was the reported colony found actually to exist where stated, but also it was learned that three others had become established in the same district.

Of the four colonies mentioned, only one was personally inspected. Unfortunately, it was not found until the last day alloted to this phase of the summer's work and time was pressing. This particular colony was located about one half-mile from Frenchman River between the lower reaches of Big and Little Breed creeks. It covers many acres on a dry flat that stretches for miles along the Frenchman. The habitat is apparently typical with sparse, shortgrass cover sprinkled with clumps of greasewood and sagebrush. On the whole, conditions are similar to those existing at the "Prairie-dog Buttes" town, but there is a greater abundance of greasewood than farther up the valley. Zonal characteristics are strongly Upper Sonoran. Elevation of the bottomlands near the junction of Frenchman River and Breed Creek is approximately 2,500 feet. The main valley is apparently two to three miles in width, with a depth of 300 to 400 feet. Parts of the environment are extremely rugged with badlands formations and deep, tributary coulees.

For information on the other three prairie-dog towns, I am indebted to Mr. E. Hanson, a rancher who lives near the mouth of Little Breed Creek. He carefully indicated the position of these on a large-scale township sketch map, which I now have on file. The largest of these prairie-dog settlements is located a few hundred yards westward of Frenchman River in the NW$\frac{1}{4}$ of section 27, township 1, range 11, west of the third meridian. Probably this is the dog town that I heard about in 1927, as it lies nearly midway between the mouths of Little Breed

and Otter creeks, although on the opposite side of the Frenchman. It is the southern-most habitation of the species known in Canada. Also west of the river is another town of smaller size in the NW¼ of section 5, township 2, range 11; this, also, is only a short distance from the banks of the stream. The fourth and last colony differs from the others in being fully 1.5 miles from Frenchman River in the vicinity of Big Breed Creek; it lies in the eastern half of section 15, township 2, range 11, and about 3.5 miles north of the dog town first mentioned in this paragraph.

All four of these colonies come within a circle having a radius of a little less than two miles. Their mean distance due north of the International Boundary is 6.6 miles, and from the latter, in an airline up the Frenchman River, 8.5 miles. Investigations showed that no prairie-dog towns exist in the valley between those mentioned above and the Saskatchewan-Montana boundary. Likewise, there is said to be no colonies between those in the Breed Creek sector and the big town up-stream at "Prairie-dog Buttes"— approximately 11.5 miles to the northwest. The latter is the northern-most *Cynomys* establishment known to exist at present in Western Canada.

It is now seen that five colonies of these animals are located in Saskatchewan. All are rooted on the bottomlands of Frenchman River Valley; none is known to occur anywhere on the high plains of the Missouri watershed on the Canadian side of the border. Based on these facts, it seems plain that only through the existence of the deep valley of the Frenchman acting as a gateway to the north has the prairie-dog found conditions congenial for an intrusion into Canada. While camped in the valley at the International Boundary, I inquired of a Montana rancher as to the nearest prairie-dogs along the Frenchman River to the south. So far as I could gather, such obtain only between 20 and 30 miles below the border, or probably not far north of the confluence of Frenchman and Milk rivers. Thus, there is apparently a long stretch of perhaps 30 miles, or more, along the Frenchman between Breed Creek and Milk River where no prairie-dog towns have been established.

In my earlier paper (1938) on the species, I mentioned on page 293 that a small prairie-dog town had been reported a few miles south of Supreme, Saskatchewan (T. 2, R. 26, W. of 3rd Mer.). Ostensibly, it was situated in the valley of Battle Creek, as no colonies have ever been found in Canada on the high plains. In June, 1942, I had an opportunity to check up on this matter. Battle Creek Valley was carefully examined from Supreme almost to the International Boundary without finding any evidence of prairie-dogs, old or recent. The question was also discussed with several men who knew the country, all of whom asserted that they had no knowledge of prairie-dogs anywhere in the district. One rancher stated, however, that he had seen these animals along Battle Creek, in Montana, some miles north of its confluence with Milk River. It therefore still appears to hold that the only *Cynomys* in Western Canada are located in the Frenchman River Valley.

Contribution of the National Parks Bureau, Department of Mines and Resources, Ottawa.

National Parks Bureau, Dominion Public Building, Winnipeg, Manitoba, Canada.

FOOD REQUIREMENTS OF SOME ALASKAN GAME MAMMALS

By L. J. Palmer

The determination of range grazing capacity for game is essential in wildlife management. It is receiving increased attention. This contribution in that field results from wildlife investigations in Alaska.

In the Southwest, Nichol (1938, pp. 39), working with deer, has determined a requirement of 2.35 pounds (air dry weight) of forage for each 100 pounds live weight a day. Biologists engaged in present studies of deer ranges in Colorado (Anonymous, 1940) have adopted Nichol's findings in application to the grazing capacity problem and have assigned a requirement of 5 pounds of feed a day or 150 pounds a month a deer for purposes of calculation. A report on digestion experiments with white-tailed deer in Pennsylvania (Forbes and others, 1941) states "The deer ate the several rations used in similar amounts, about 700 grams (a little more than 1½ pounds) a day, and made slight gains in live weight." Animals utilized in the tests were young deer weighing 45 to 50 pounds. It is indicated in this case that the food requirement was approximately 3.24 pounds of forage for each 100 pounds live weight a day.

The Alaska information may be of similar and additional value to the determination of game animal forage requirements and its application to range grazing capacity.

Investigations in Alaska since 1920 by the Biological Survey (now Fish and Wildlife Service) considered not only reindeer and caribous but also musk oxen, mountain sheep, buffaloes and moose. During the past three years the investigations have been confined to game species, including Sitka deer. Studies have consisted, among other things, of forage inventory and observations of range use by game animals as well as determination of food requirements in the feedlot. The feedlot experiments are especially interesting.

FEEDING TESTS WITH MUSK OXEN, REINDEER AND CARIBOUS

During 1931–33, at the former Biological Survey Experiment Station at Fairbanks, Alaska, feeding and digestion tests with musk oxen, reindeer and caribous were conducted (Palmer and Kennedy). In the experiments with musk oxen, the animals first employed were calves (10 months old). These same animals were continued in successive tests until three years old. The reindeer and caribous included fawns (11 months old), yearlings, and adults. A review and summary of the feeding results is given below.

SUGGESTED FOOD REQUIREMENT FOR ALASKA GAME ANIMALS

Based on these feeding tests with caribous, reindeer and musk oxen, the following food requirements (air dry weight of forage) for the various game animals in Alaska are suggested:

250-lb. caribou	10 lbs. a day	300 lbs. a month
500-lb. musk ox	10 lbs. a day	300 lbs. a month
1200-lb. moose	35 lbs. a day	1050 lbs. a month

200-lb. Dall sheep	6 lbs. a day	180 lbs. a month
150-lb. Sitka deer	5 lbs. a day	150 lbs. a month
1000-lb. buffalo	30 lbs. a day	900 lbs. a month

The caribou is a fastidious feeder, utilizes a smaller percentage of the forage, requires a larger amount when feeding on lichens, and therefore requires a proportionately larger daily ration as compared with the musk ox. For the moose, mountain sheep, deer, and buffalo, the average of the musk ox and caribou requirement is adopted for calculation. The indicated sustaining feed per diem a 100 lbs. live weight, on the basis of the feed as fed, is used in this compilation.

TABLE 1.—*Summary of feeding tests with musk oxen*

10 DAY FEEDING TRIAL (FOLLOWING TWO WEEKS PRIOR FEEDING PERIOD)			FEED PER HEAD PER DAY (AIR DRY WEIGHT)				INDICATED SUSTAINING FEED PER DAY			
Number of animals	Average weight of animals		Average loss or gain	Kind	Amount		Per animal used in test		Per 100 lbs. live weight	
	Start	End			Fed	Eaten	As fed	As eaten	As fed	As eaten
					lbs.	*lbs.*				
4	141.25	140.4	−0.85	Alfalfa	3	2.59				
4	143.6	148.9	5.3	"	3.5	2.71	3.25	2.65	2.29	1.87
3	142.3	145.8	3.5	Lichens	5	2.59	5	2.59	3.52	1.83
4	234.5	235.0	0.5	Native hay	4	3.60				
4	232.25	233.0	0.75	" "	4.5	4.26	4.25	3.93	1.82	1.69
3	201	204.5	3.5	Sedge hay	4	3.60				
3	201	203.65	2.65	" "	4.5	4.27	4.25	3.43	2.11	1.71
4	238.75	243.25	4.5	Vetch-oats	5	4.80				
4	252.5	257.1	4.6	" "	4.36	4.14	4.66	4.47	1.90	1.83
3	199.2	208.8	9.6	Pea hay	5.44	5.17				
3	204	200.3	−3.7	" "	4	3.25	4.5	4.01	2.23	1.99
3	325.33	323.33	−2.0	" "	5.25	4.77				
3	331	332.33	1.33	" "	4.66	4.37	5	4.57	1.52	1.39
4	360.75	369.5	8.75	Oat hay	5.75	5.06	5.5	4.84	1.53	1.35
3	271.33	268.0	−3.33	Brom hay	4	3.93	4.5	4.42	1.66	1.63
3	391.33	391.33	0	Vetch hay	6.75	6.58				
3	394.66	396.66	2.0	" "	6.75	6.58	6.75	6.58	1.72	1.67
Average									2.03	1.70
Feed requirement for 500 lb. musk ox a day									10.15	8.50
Feed utilized									84 per cent	

TABLE 2.—*Summary of feeding tests with reindeer and caribous*
(Feeding trial—20 days to 1 month)

10 DAY FEEDING TRIAL (FOLLOWING TWO WEEKS PRIOR FEEDING PERIOD)			FEED PER HEAD PER DAY (AIR DRY WEIGHT)				INDICATED SUSTAINING FEED PER DAY			
Number of animals	Average weight of animals		Average loss or gain	Kind	Amount		Per animal used in test		Per 100 lbs. live weight	
	Start	End			Fed	Eaten	As fed	As eaten	As fed	As eaten
					lbs.	*lbs.*				
2	268.25	273.5	5.25	Lichens with oats	13	6.75	11	5.71	4.11	2.13
2	271.5	263.5	−8	Lichens	14.6	5.41	16	5.93	5.80	2.18
2	275	274	−1	Alfalfa	10	4.34	10	4.34	3.64	1.58
4	150	147.4	−2.6	Pea hay	4	3.46				
3	151.33	144.33	−7.0	" "	5	2.21	5.5	3.50	3.66	2.33
3	124	122.2	−1.8	Vetch-oats	2	1.65				
3	126	120.0	−6	" "	3	2.42	3.5	2.85	2.80	2.28
3	210.66	189.33	−21.33	Pea hay with oats	3.45					
3	189.33	178.66	−10.67	" "	4.46		5.5		2.75	
5	207.2	215.3	8.1	Alfalfa with grain	7.16		7		3.38	
6	134.2	137.3	3.1	" "	5.0		5		3.73	
8	176.4	172.3	−4.1	Alfalfa with oats	6.0					
8	172.3	185.3	13.0	" "	6.5		6.25		3.59	
8	185.3	193.5	8.2	Alfalfa meal with oats	7.4					
8	193.5	202.9	9.4	" "	7.74					
8	202.5	217.9	15.0	" "	8.73		7		3.61	
Average									3.70	2.10
Feed requirement for 250 lb. caribou a day									9.25	5.25
Feed utilized									57 per cent	
Average of the musk ox and caribou requirements per 100 lbs. live weight									2.85	1.90

This is necessary to take care of the factor of residue or unused parts of the range feed if the figure is to be applied in a measure of range carrying capacity by the method of plot cuttings for forage yield.

THE LICHEN AS A FOOD

In feeding on lichens as well as on other foods in general, musk oxen appear to utilize feed much better than reindeer and caribous. For musk oxen the percentage of feed utilized, as an average of all tests, was about 84 percent as compared with only 57 percent for reindeer and caribous. In feeding lichens alone, the use was about 52 percent for musk oxen and about 37 percent for reindeer and caribous.

The lichens fed were of the tall growth or moist-site forms (largely *Cladonia* and *Cetraria* spp.). These are the more abundant and accessible and therefore the ones mostly eaten by the reindeer and caribou as compared with the less accessible short-growth or dry-site forms (such as *Alectoria*, certain species of *Cladonia* and *Cetraria*, *Nephroma*, *Lobaria*, *Parmelia*, *Peltigera*, *Thamnolia*, *Stereocaulon* and *Sphaerophorus*). A pasturage study comparing the use of short-growth lichens with tall-growth lichens resulted in gains on the short-growth forms as against losses on the tall-growth type. In pasturing 14 reindeer and caribous on a short-lichen type of range during January 1928, the average daily gain an animal was 0.119 pounds. In pasturing 14 animals on a tall lichen type of range during February, March, and the fore part of April 1928, the average daily loss an animal was 0.0144 pounds. A fall study during October 1928, with 16 reindeer and caribous pastured on tall lichen range, showed an average daily loss an animal of 0.066 pounds. A pasturage test with 16 animals on a mixed forage range, comprising about one-half lichens and one-half herbaceous vegetation, during November 1928 resulted in an average gain an animal a day of 0.232 pounds. A continued test on a sedge and browse pasture without lichens during December 1928 resulted in an average loss an animal a day of 0.107 pounds. It is indicated from this that while the short-growth lichens may be superior to the tall-growth forms in nutritive value, the latter in fall and winter are superior in full or at least in part to a non-lichen diet.

A determination of the vitamin contents of the two classes of lichen forage by feeding to rats (Ellis and others, 1933) revealed interesting differences. In composition, the short lichens proved much higher in protein than the tall lichens, approximately at the ratio of 2.6 to 1. An absence of vitamin B-complex was found in both classes of lichens. Vitamin A was absent in the tall-growth lichens but present in fair amount in the short-growth lichens. Vitamin D was found in fair amount in the short lichens but of superior amount in the tall lichens.

The superiority of the short lichens in protein and in vitamin A may account in part for pasturage gains on this forage. The deficiency of vitamins A and B-complex in the tall lichens, which are the chief winter food of reindeer and caribou, suggests a possible factor in the prevalence of skin and other afflictions in reindeer and caribous, such as, dermatitis, keratitis and warts. The presence of vitamin D in both lichens may explain the scarcity of rickets in reindeer and caribou.

The tall lichens were not palatable to rats and few survived for any extended time when fed at levels greater than 10 percent. The short lichens were well

tolerated at the levels fed. Reindeer and caribous, on the other hand, prefer the tall lichens.

Lichens are essential for winter forage in the maintenance of reindeer and caribous. They are also eaten to some extent by other game ruminants excepting perhaps buffaloes. Where the lichens have been destroyed by fire as on Kenai Peninsula and lower Susitna Valley, Alaska, the caribous have disappeared. Because of change in cover, however, and invasion of birch, aspen, and willows, the moose have greatly increased on these areas.

GAME ANIMAL DENSITY IN ALASKA

General observations and study of specific areas in Alaska indicate that the population density of game animals within their habitat is about as follows:

Caribou	5–10 animals to the square mile
Moose	1–1½ " " " " "
Dall sheep	1½–3 " " " " "
Sitka blacktail deer	1–2 " " " " "

Under natural conditions of environment, population density is limited by factors of climate, such as recurrent years of deep snow or icing of vegetation, the presence of predators, density of cover, and restricted winter ranges. The last is particularly important in Alaska and in large measure determines the grazing capacity of the range. The occupation, however, may fluctuate considerably with cyclic weather changes over a period of years or with changes in cover caused by fire.

It is also the thought, in considering range capacity, that as compared with domestic livestock, game species will require a larger acreage for their maintenance by reason of their greater mobility on the range, need for shelter, peculiarities of feeding or other range habits, and subjection to parasitism and disease where they are crowded.

PRINCIPAL FORAGE EATEN BY ALASKA GAME MAMMALS

Through observations on the range, feeding and pasturage tests, and examination of stomachs, it has been determined thus far that the principal forage eaten by game animals in Alaska is as follows: Key plants only are listed. In addition, in each case, numerous other plants are eaten to a minor extent.

Caribou.—Willows (*Salix*), sedges (*Carex, Eriophorum*), grasses (*Festuca, Poa, Hierochloa, Calamagrostis, Arctagrostis, Phleum*), woodrush (*Luzula*), horsetail (*Equisetum*), blueberry (*Vaccinium*), ground birch (*Betula*), mountain cranberry (*Vaccinium vitis-idaea*), Labrador-tea (*Ledum*), crowberry (*Empetrum nigrum*), lichens (*Cladonia* and *Cetraria* chiefly).

Sitka Deer.—Red huckleberry (*Vaccinium parvifolium*), blueberry (*Vaccinium ovalifolium* and *alaskaense*), western red cedar (*Thuja plicata*), Alaska cedar (*Chamaecyparis nootkatensis*), western hemlock (*Tsuga heterophylla*), mountain hemlock (*Tsuga mertensiana*), trailing bramble (*Rubus pedatus*), herbaceous dogwood (*Cornus canadensis*), tall salmonberry (*Rubus spectabilis*), alder (*Alnus*), elderberry (*Sambucus*), mountain-ash (*Sorbus*), mountain maple (*Acer*), skunk cabbage (*Lysichiton americanum*), sedges (*Carex*), grasses (undetermained).

Moose.—Birch (*Betula*), ground birch (*Betula*), willows (*Salix*), mountain-ash (*Sorbus*), currants (*Ribes*), service berry (*Amelanchier*), elderberry (*Sambucus*), aspen (*Populus tremuloides*), raspberry (*Rubus*), cottonwood (*Populus*), alder (*Alnus*), highbush cranberry (*Viburnum*), blueberry (*Vaccinium*), sedges (*Carex*), grasses (*Festuca, Poa, Calamagrostis, Bromus, Agropyron*), horsetail (*Equisetum*), pondweeds (undetermined).

Musk Ox.—Willows (*Salix*), aspen (*Populus tremuloides*), sedges (*Carex, Eriophorum*), grasses (*Calamagrostis, Agropyron, Poa, Festuca, Phleum, Hierochloa, Glyceria*), woodrush (*Luzula*), horsetail (*Equisetum*), raspberry (*Rubus strigosus*), alder (*Alnus*), cottonwood (*Populus*), birch (*Betula*), ground birch (*Betula*), blueberry (*Vaccinium*), lichens (*Cladonia, Cetraria*).

Dall Sheep.—Mountain avens (*Dryas*), willows (*Salix*), sedges (*Carex*), grasses (*Poa, Hierochloa, Festuca, Agropyron, Phleum, Calamagrostis*), ground birch (*Betula*), blueberry (*Vaccinium*), saxifrage (*Saxifraga*), horsetail (*Equisetum*), loco (*Astragalus, Oxytropis*), jointpod (*Hedysarum*), lichens (*Cladonia, Cetraria, Alectoria*).

Buffalo.—Grasses (*Agropyron, Poa, Festuca, Elymus, Trisetum, Hierochloa, Calamagrostis, Agrostis*), sedges (*Carex*), sage (*Artemisia*), loco (*Astragalus, Oxytropis*), jointpod (*Hedysarum*), yarrow (*Achillea*), horsetail (*Equisetum*), peavine (*Lathyrus*), ground birch (*Betula*).

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FOOD HABITS OF RED FOXES OF THE MARYLAND MARSHES

By William S. Heit

The purpose of this investigation was to determine the status of the red fox (*Vulpes fulva*) in the muskrat marshes of the Eastern Shore of Maryland. The menace of the red fox is much discussed by the trappers and owners of the salt and fresh water marshes. Smith (1934) stated that red foxes sometimes kill muskrats and are particularly destructive where they have dens on small islands in the marshes. He believed that muskrats are a favorite prey of the foxes, particularly during the season when they are rearing their pups. Only the red fox occurs on the area studied. This was corroborated by trappers and also by fur buyers some of whom have bought furs in this area for 30 years.

This food habit study covers the period from March 1939 through August 1939, and is based on 95 fox scats, of which some were collected each month, on the Blackwater marhes on and near the Blackwater National Wildlife Refuge in Dorchester County. This area of approximately 10,000 acres is bordered by woods and fields. The marshes are divided by the Blackwater River that runs through them to the bay and are dotted with small islands varying in size from a half acre to 10 acres. The water is fresh or salt depending on accessibility to the tides. The main vegetation is three-square (*Scirpus olneyi*), bordered by salt grass (*Distichlis spicata*), and including clumps of cattail (*Typha latifolia*) and saltmarsh bulrush (*Scirpus robustus*). The scats were collected two or three times a month from the marshes and immediately adjacent areas. Many of them were found on muskrat houses far out in the marshes and along regular fox paths through the marshes and along the edges. The borders of certain islands and banks of ditches that drain the fields, near the marshes were profitable collecting areas. Occasionally scats were collected along paths in the fields and along construction and observation roads that cross the marshes at numerous points.

The fox scats are reported upon by months in the following tables in which the food items are listed according to the percentage of frequency of occurrence.

These analyses by months were made with the purpose of learning what change there might be in the food habits of the foxes during the spring and summer and when it occurs. Unfortunately, the number of scats collected during May, June, and August was not large enough but it was evident that field mice not only comprised a large proportion of the food but were taken all through the season. However, the intensity with which they were utilized varied according to the period and also according to the availability of muskrats. The occurrences of field mice in the scats reached their peak in April and May, and then fell off in July, at which time the frequency of occurrence of muskrats reached its peak. In June and July muskrats occurred more frequently than did field mice, and in the other months—March, April, May and August—the field mice outnumbered muskrats. Cottontail rabbit remains were found frequently in the scats collected in early spring but failed to appear in scats collected after April. Birds seemed to form a steady part of the diet of the red fox throughout the season, with little change in frequency of occurrence.

The habits of the fox in this area together with those of the animals it feeds upon, account for its changes of diet from one period to another. Throughout the winter and early spring the foxes do not inhabit the marsh area but roam the

TABLE 1.—*Monthly analysis of red fox scats collected in 1939 on the Blackwater Marshes, Dorchester County, Maryland*

DATE	FOOD ITEMS	OCCURRENCES	PERCENTAGE OF FREQUENCY
March 10	Microtus	5	50.0
	Ondatra zibethica	5	50.0
	Sylvilagus	3	30.0
	Peromyscus	1	10.0
	Undetermined small mammal	1	10.0
	Birds	4	40.0
	Seeds	2	20.0
April 14	Microtus	29	65.9
	Ondatra zibethica	9	20.4
	Sylvilagus	8	18.1
	Peromyscus	5	11.3
	Oryzomys	1	2.3
	Undetermined small mammals	4	9.0
	Birds	9	20.0
	Insect	1	2.3
	Seeds	4	9.0
May 3	Microtus	3	100.0
	Ondatra zibethica	1	33.4
	Insect	1	33.4
June 7	Microtus	3	42.8
	Ondatra zibethica	5	71.4
	Undetermined small mammal	1	14.3
	Insect	1	14.3
July 25	Microtus	3	12.0
	Ondatra zibethica	16	64.0
	Undetermined small mammals	5	20.0
	Birds	4	16.0
	Insects	5	20.0
	Seeds	4	16.0
August 6	Microtus	4	66.5
	Ondatra zibethica	1	16.5
	Undetermined small mammals	2	33.3
	Bird	1	16.5

nearby fields and woods. The main reason is the fact that the marsh is very heavily trapped for muskrats during the winter and spring, and the frequent appearance of trappers drives the foxes away. They still frequent the borders but do not penetrate the marsh as far as they do in summer. Further, in early spring

the water is quite high and this tends to prevent heavy use by the foxes until the marshes begin to dry in May. Thus limited in March and April, the foxes take more rabbits although they prey to some extent upon muskrats on the border of the marsh. As soon as the marshes are relatively dry, however, in late April and May the foxes again frequent them and seldom take rabbits. The fact that the greatest consumption of muskrats occurs in June and July may be attributed to a combination of two factors: first, the marsh gets drier and there is a concentration of muskrats in the wetter area; and also the muskrats that do remain in the dry spots of the marsh are easier prey for the foxes than they would be if there were ample water around their houses and holes; and second, the first litters of young muskrats are large enough to wander about, providing possibly easier prey than do the field mice. Since the time needed to catch one muskrat would be much less than that required to catch 12 to 15 field mice, which would about equal the muskrat in food value, the fox may find muskratting more profitable.

TABLE 2.—*Seasonal analysis of 95 red fox scats collected on the Blackwater Marshes, Dorchester County, Maryland*

	OCCURRENCES	PERCENTAGE OF FREQUENCY	
Mammals	93		97.8
Microtus	47	49.4	
Ondatra zibethica	37	38.9	
Sylvilagus	11	11.5	
Peromyscus	6	6.3	
Oryzomys	1	1.0	
Undetermined small mammals	13	13.6	
Birds	18		18.9
Insects	9		9.4
Seeds	10		10.5

A summary of the total (95) scats collected from March to April reveals the following percentages of occurrence.

Field mice were the most important food item of the red fox. Hamilton (1935) also found that mice comprised the major part of the red fox's diet in the northeast as did Hatfield (1939) in his investigations in Minnesota.

The extent to which muskrats were utilized by the foxes is of interest. Muskrat remains were found in 38.9 percent of all the scats, which indicates a far larger depredation on muskrats than was suspected. Many of the scats examined contained 100 percent muskrat. The muskrats suffer so greatly in this area largely because of their peculiar habitat and their abundance. The number of muskrats trapped each year have varied from 20,000 to 36,000, indicating that this item of fox prey is available in large numbers the year round. The fact that the red fox has dens on the islands in the marshes, is rather curious and indicates a distinct change from the habits of the species elsewhere. Whether this is caused by the concentrations of muskrats and field mice on the marsh is not definitely proved but is probable.

Birds are an important item (18.9 percent) on the fox menu and occur with astonishing regularity. Many of those taken were small birds and often their remains made up a small proportion of the scats but only two scats were examined in which bird remains were more than 50 percent of the bulk. Some of the birds were identified as *Galliformes* but in most cases the material was recognizable only as being of bird origin.

Undetermined small mammal remains with a frequency of 13.6 percent were usually fur about which only a guess could be hazarded. This undetermined material may have represented either mice or young muskrats.

Insects occurred in 9.4 percent of the scats but in no case did they make up the major portion of a scat. Beetles, grasshoppers, and crickets, were recognized.

Seeds were found in 10.5 percent and were mainly those of persimmon (*Diospyros virginiana*) and dewberry (*Rubus*). In only one instance did the persimmon seeds make up a large proportion of a scat but it is well known that the foxes are fond of persimmons in this area. The trappers make fox sets on trails leading to persimmon trees and around the trees and catch many foxes in them.

The high frequency of occurrence of muskrat remains in the scats substantiates the reports of trappers and marsh owners that foxes in the Blackwater Area are a menace to the muskrat population. The fact that muskrats were found in 37 of 95 scats indicates that such predation is of importance in Dorchester County and probably in similar nearby areas. However, this preliminary study merely emphasizes the need for a more complete investigation of the red fox in this region. The fact that the animal takes a heavy toll of the mice population of the fields and marshes must be considered. Many other factors should also be carefully studied and considered before any decision is made as to wholesale eradication of the red fox.

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NOTES ON GROWTH, SEX AND AGE RATIOS, AND SUGGESTED MANAGEMENT OF MINNESOTA MUSKRATS

By Lester J. McCann

During 1941, there were both spring and fall trapping seasons for muskrats in Minnesota. It was felt that information on sex ratios, age classes, growth, and management might be obtained from a study of skinned carcasses collected during the seasons followed by a comparison of the results. Accordingly, skinned muskrat carcasses were obtained from trappers in most of the important areas of the state during the two seasons. The carcasses were brought to the laboratory and studied for the desired information.

One thousand ninety-four skinned carcasses were collected in the spring season of March 19 to March 31. In the fall season, December 1–21, 610 were obtained. The carcasses were measured, sexed, weighed, and the females examined for pregnancy. In addition, in fall specimens the embryonic scars were counted in each adult female and the animals were grouped into adult and juvenile classes. The technique of determining age-classes was demonstrated to us by Errington as reported by him (1939).

WEIGHTS AND MEASUREMENTS

Carcasses taken in the spring averaged 885.3 grams; in the fall, 740.2 grams. Thus, muskrats taken in December averaged 145.1 grams (16 percent) less. This is also borne out by animals collected from the same areas during the two seasons. In the spring, 112 carcasses, collected from the Mississippi River bottoms in the vicinity of Wabasha, averaged 926.1 grams; in the fall, 64 carcasses weighed 794.3 grams, or 131.8 grams (14.2 percent) lighter. In the Minnesota River bottoms, the average for 67 spring-taken carcasses was 909.4 grams; 753.4 grams for 73 fall-taken carcasses. These fall-taken animals averaged 156.1 grams or 20.7 percent less.

It is likely that spring-caught muskrats averaged heavier because of added growth of the young during the winter. This is borne out by the fact that the average of all carcasses in the spring, both young and mature, was only slightly less than the average of mature animals in the fall (885.3 grams as compared with 894.8 grams). The immature animals in the fall averaged 687.2 grams. Under normal conditions, therefore, young muskrats grow somewhat during the winter months.

The largest carcass, collected from Isanti County, weighed 1,480 grams. Limited studies on five individuals indicated that a muskrat in its entire condition weighs about 20 percent more than the skinned carcass as used in this study. This animal in its entire condition probably weighed close to 1,775 grams. Buss (1941) records a maximum weight of 1,644 grams for a muskrat in its entire condition.

Carcasses collected from different areas varied considerably in weight. One group of 20 from a lake in Anoka County averaged only 695 grams, or 190 grams below the mean; and, except for one carcass that weighed 868 grams, every indi-

vidual in this group was below average. On the other hand, a group of 16 carcasses from Dakota County, collected from a river-bottom habitat, averaged 1,025 grams, or 140 grams above the mean and 330 grams more than the low group from Anoka County. It was apparent from this study that the size of muskrats varied with habitat conditions. The river-bottom type of habitat usually produced the largest carcasses. Local fur buyers report that quality of pelts likewise grades highest from this type of habitat. Later studies suggested the abundance of duck potatoes, *Sagittaria*, as contributing heavily to the superiority of the river-bottom areas.

Total lengths of the carcasses substantiates the evidence obtained by weights. The average of 277 individuals measured in the spring was 564.7 mm as compared with 545.6 mm for 518 fall-caught animals. Thus, the later group averaged 19.1 mm, or 3.3 percent, shorter. In the fall, the mean for 149 adults was 572.7 mm as compared with 534.7 mm for 369 young. Juveniles, therefore, were 38 mm, or 6.6 percent, shorter than adults. Total lengths did not vary as measurably as did weights.

These data indicate that some accumulated growth is lost by trapping muskrats in the fall. It does not follow, however, that this fact overshadows some of the obvious advantages of fall trapping.

AGE-CLASSES

Of 567 fall-caught animals examined for age-classes, 155 were adults; 412, juveniles. This showed the catch to be composed of 72.6 percent young of the year. In the spring study, it was assumed all animals could be classified as adults.

From the above data, it is assumed that the muskrat population was at a medium level. This assumption is based on the evidence that the number of barren females was high and the ratio of young to adults caught was great. As the population increases, the ratio of young to adults should be reduced to more equal numbers, for, as Errington (1940) points out, a reduction in the numbers of young successfully raised occurs as the population becomes higher.

SEX-RATIOS

Among the spring-trapped animals, 45 percent were females; 55 percent, males, giving a ratio of 1 female to 1.22 males. Hatfield (1939) found a ratio of 1 female to 1.3 males in 484 carcasses collected in Minnesota between March 20 and 24, 1938.

In fall-caught animals, the sex-ratio was found to be 1 female to 1.18 males. This was almost the same as the spring ratio. There is no reason why trapping as conducted in either season should have favored one sex over the other. In both seasons, trapping was conducted for the most part when the lakes were covered with ice and the movements of the animals were rather restricted. It is probable, therefore, that the sex-ratio in the period between spring and fall is in the neighborhood of 1 female to 1.2 males. At any rate, the population is composed of more males than females.

Of the 155 fall animals determined to be adults, 85 were females and 70 were

males, giving a fall adult sex-ratio of 1.2 adult females to 1 adult male. This is just the reverse of the adult sex-ratio in the spring when all animals would be classed as adults in March. Of the 412 fall-trapped individuals determined to be young of the year, 175 were females and 239 were males, giving a sex-ratio in young animals of 1 female to 1.3 males.

Since the fall sex-ratio among mature animals shows more females, and the spring sex-ratio more males, it necessarily follows that some mortality factor operates disproportionately against the male muskrat between spring and fall. Evidently a preponderance of males in the young of the year compensates for this loss.

Mortality among male animals probably results from strife during the breeding season and as a result of various causes during their spring and summer wanderings. Errington (*op. cit.*) found 52.3 percent males for 595 Iowa muskrats caught in November, 1936, and December, 1936–38. Males comprised 55.1 percent of 463 young of the year, but only 42.3 percent of 132 adults in his study. He likewise suggests that a differential spring and summer mortality of male muskrats occurs from natural causes.

Errington (*op. cit.*) suggests that muskrats are loosely monogamous. A scarcity of male animals, therefore, should result in a commensurate number of unbred females. As will be seen later, a considerable number of barren females was in this study. Late spring trapping when the animals are moving about freely results in a disproportionate catch of male animals. Trapping of muskrats at this time of year, therefore, should not be permitted.

NUMBER OF YOUNG

During our spring examinations, only one pregnant female was found in the 492 examined. However, the testes of 50 percent of the males examined were descended and in a swollen condition, indicating that the main breeding season was close at hand. In his late March examinations, Hatfield (1939) found two of 207 females that contained small embryos. It is likely, therefore, that the breeding season is just beginning during the month of March in Minnesota.

Of the fall animals determined to be adult females, 67, or 78.8 percent, possessed placental scars, indicating that they had borne young that year. Eighteen females had all the characteristics of being adults, but possessed no placental scars, indicating that they did not produce young that year. Thus, 21.2 percent of the adult females examined were barren. Errington (*op. cit.*) found in a study of carcasses from Iowa that only five percent of the adult females were barren. This low percentage of barren females in Iowa may result from the absence of late spring trapping.

Of the animals examined there was a ratio of one adult female per 4.8 young. If only the adult females that had had young are considered, the ratio rises to one adult female per 6.1 young successfully reared to trapable age. This figure indicates that the muskrat is not so prolific as it is sometimes thought to be.

The embryonic scars in each adult female were counted, and the weighted average was found to be 11.5 per breeding female. This suggests that the

female muskrat normally produces two litters of about six individuals a year. Since the number of young trapped per breeding female is 6.1, it further suggests that only about 53 percent of the young reach a trapable age.

Errington (*op. cit.*) found that under ideal conditions as many as 19 young are born per breeding female in Iowa. He states that a relationship exists between food conditions and the number of young per adult female successfully reared. In our study, one adult female had 19 embryonic scars, two had 20, three had 21 and two had 23. In Minnesota, therefore, it is likewise possible that under ideal conditions female muskrats may rear 19 or more young per year.

LIFE EQUATION

The following life equation, based on data presented in preceding paragraphs, shows the losses necessary to account for the difference in sex ratios.

	POPULATION CHANGES		TOTAL POPULATION
	Juveniles	Adults	
Sample spring population of 55 males and 45 females (based on a spring sex ratio of 1 female to 1.22 males)	—	—	100
Maximum number of young produced (based on 78.8 percent of females having an average of 11.5 young)	+407	—	507
Adult fall population of 38 males and 45 females (based on a fall sex ratio of 1.2 females to 1 male) assuming no loss in females	—	−17	490
December trapping season population. (A computed summer juvenile mortality of 47 percent as indicated by the number of young per female as compared with the number of placental scars)	−191	—	299

The increase between spring and trapping time in December would be 299 minus 100, or 199 individuals.

Theoretically, 199 individuals, or 66.5 percent, of the December population could be removed without reducing the population beyond the original 100 if no winter loss was experienced. However, there are certain to be additional mortality factors so far not considered, including the reductions in the number of females in summer.

It is likely that a fall trapping season should not remove more than 50 percent of the total fall population in order to maintain an adequate breeding population. From this standpoint, successful statewide management of muskrats consists of keeping the annual take within this limit.

SUMMARY AND CONCLUSIONS

(1) The sex ratio of Minnesota muskrats in the period between fall and spring is approximately 1 female to 1.2 males.

(2) A differential spring and summer mortality reduces the number of adult males and reverses the sex ratio by fall to 1.2 adult females to 1 adult male. Since the muskrat is loosely monogamous, a decrease in number of males should result in a commensurate number of barren females. It follows that it is unwise to set trapping regulations in such a manner that a differential take of males occurs.

(3) A majority of males in the young of the year compensates for the natural losses among adult males in spring and summer.

(4) The breeding season of muskrats in Minnesota begins in late March.

(5) The female muskrat in Minnesota averages two litters a year of about six individuals each. Juvenile mortality reduces the number of young by trapping season to six young per breeding female.

(6) The size and quantity of muskrats varies with conditions under which they develop.

(7) Juvenile muskrats increase in size during the winter months.

(8) A reduction by trapping in December of not more than 50 percent of the total population is close to the safe limit for maintaining the population over a period of years.

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ABNORMAL TOOTH PATTERN IN THE LOWER DENTITION OF THE JACKRABBIT, *LEPUS CALIFORNICUS DESERTICOLA* (MEARNS)

By Claude W. Hibbard

While studying fossil and recent jaws of *Lepus*, a specimen of *Lepus californicus deserticola* (Mearns), no. 6748, Kansas University Museum of Modern Vertebrates (formerly listed as Museum of Mammals), from Bannock County, Idaho, was observed to possess a RP_3 with an abnormal tooth pattern. Those who have studied dentitions are aware of the numerous variations in tooth patterns due both to age and individual variation, as well as the occurrence of abnormal patterns. At the time of this discovery I had just finished studying a series of fossil and recent rabbit P_3's that had been sectioned at approximately every millimeter to determine as nearly as possible the change of tooth pattern due to wear and age. The abnormality observed in the RP_3 (figs. 1 & 1a) of the recent jackrabbit seems to me to be more than a fortuitous development where the primordium has failed to appear in its entirety in the development of that tooth. There seems to be evidence, from the study of the teeth of *Nekrolagus progressus* (Hibbard), that the abnormality may be an atavistic character. Figures 3a–3f, 4a–4j, and 5a–5c are of three teeth of *Nekrolagus progressus*, which are from different aged specimens. Figure 3a is the crown view of an unworn RP_3 presenting a typical palaeolagine pattern with the exception of the anterior reentrant angle. The tooth was ground down too far to show the intermediate patterns between 3a and 3b, though 3b presents a typical *Nekrolagus* pattern. Figure 5a shows the original crown view of a *Nekrolagus* tooth of an old adult. The absence of the enamel lake in 5a should not be taken as a complete absence of the lake at this time of wear. It is an isolated tooth that was badly weathered and I believe the enamel lake had been destroyed on the crown view. Figure 5b is a cross-sectional view taken 1 mm below the top of the crown. Figure 5c was the section taken 12 mm below the crown surface. Here the enamel lake is seen to become smaller, although the anterior reentrant angles were present.

I wish to point out again the occurrence of the anterior reentrant angles on P_3 in *Nekrolagus*, which is also common in *Lepus*. To develop the *Lepus* pattern from *Nekrolagus* we would need only to increase the depth of the posterior external reentrant angle to the extent that the enamel of the reentrant angle would meet that of the enamel lake and break through or increase the transverse size of the enamel lake or of both the lake and the external reentrant angle. Provided such did occur, it appears possible that there would be evidence of the junction of the enamels of the reentrant angle and the lake especially on the anterior border where there is a tendency for the enamel to thin considerably in *Nekrolagus* (see fig. 5e). I think this fusion accounts for the condition shown in figs. 2a–2c of the crown view of a recent jackrabbit where there is a considerable thinning in the anterior enamel border of the external reentrant angle. Studying the pattern of P_3 in our recent jackrabbits, one is surprised at the large amount of variation that occurs at this point in the enamel of the external reentrant angle. This variation seems to point clearly to the fact that the posterior external reentrant angle in the P_3 of *Lepus* has been formed by the union of an enamel lake and a

reentrant angle and not by the continuous development of a reentrant angle farther across the crown of that tooth to produce the reentrant angle now found

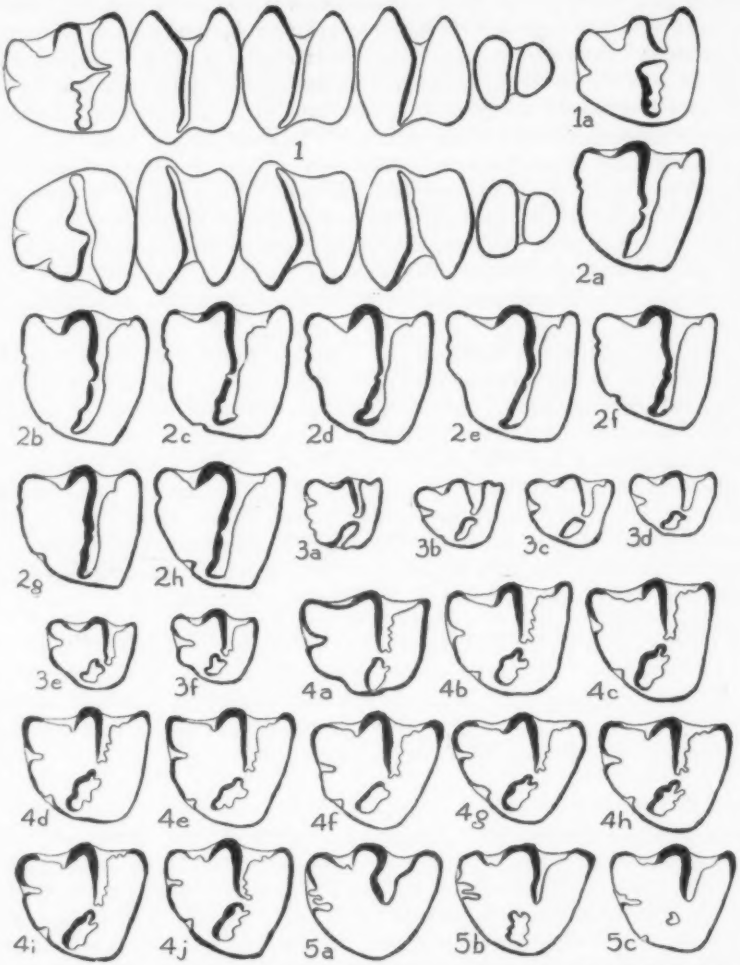

FIG. 1.—Crown view of lower R & LP_3-M_3 of Recent *Lepus c. deserticola*. Fig. 1a, cross-section view of RP_3 *L. c. deserticola*, 2.5 mm below crown. Figs. 2a-2h crown view and cross section views at approximately every millimeter of RP_3 of Recent *Lepus c. melanotis*. Figs. 3a–3f; 4a–4j and 5a-5c, crown views and sectional views of three RP_3 of *Nekrologus progressus* from the Upper Pliocene of Meade County, Kansas, Rexroad fauna. Fig. 3, unworn premolar; fig. 4, adult tooth; fig. 5, old adult tooth x6. Drawing by Frances Watson.

in *Lepus*. The following seems to indicate the development of the genus *Lepus* from an earlier species of *Nekrolagus* or a *Nekrolagus*-like form, since it is the only

known fossil rabbit that possesses dental characters from which we could develop *Lepus;* (1) the occurrence of the anterior reentrant angles; (2) the position of the enamel lake between the lingual enamel wall of the tooth and the posterior external reentrant angle in *Nekrolagus;* and (3) the observed pattern of the anterior enamel border of the posterior external reentrant angle in *Lepus,* which appears to be the result of the fusion of an enamel lake and a reentrant angle.

Figure 1 shows the complete lower dentition of *L. c. deserticola.* Figure 1a shows a cross-section view of the same tooth taken at 2.5 mm below the crown. It must be remembered that cross-section views will not give an identical pattern of a crown view of the same tooth that has been worn down to the same level, since P_3 is set in the jaw at a slight angle and wears at an angle while in the cross-section view the tooth was ground at right angles to its longitudinal axis.

A study of the embryological development of the permanent dentition of *Lepus* may give more evidence regarding the structure of P_3 and its past relationship to fossil forms.

The 142 specimens of *Lepus* in the Kansas University Museum that were examined were found to possess normal dentitional patterns of P_3, although individual variation was great. These include *Lepus townsendii campanius* Hollister, 63; *L. americanus americanus* Erxleben, 3; *L. a. virginianus* (Harlan), 2; *L. a. phaeonotus* Allen, 2; *L. bairdii cascadensis* Nelson, 1; *L. alleni alleni* Mearns, 6; *L. californicus californicus* Gray, 1; *L. c. richardsonii* (Bachman), 2; *L. c. deserticola* (Mearns), 4; *L. c. eremicus* (Allen), 1; *L. c. texianus* (Waterhouse), 1; *L. c. melanotis* (Mearns), 51; *L. c. merriami* (Mearns), 4; *L. granatensis* (Rosenhauer), 1.

I wish to thank Mr. C. D. Bunker, Curator of the Museum of Modern Vertebrates, for the privilege of studying the collection under his care.

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THE BIPEDAL WALKING OF THE CHIMPANZEE

By Herbert Elftman

The fact that some of the anthropoid apes can, on occasion, forsake their traditional quadrupedal habits and walk on two legs invites comparison between simian bipedality and that of man. Recent investigations of human walking and of quadrupedal progression have made possible a more precise approach to this problem.

Successive stages of chimpanzee quadrupedal and bipedal steps are shown in figure 1, traced from slow-motion pictures taken of Meshie some time ago, through the kindness of H. C. Raven, of the American Museum of Natural History. For comparison, a human step, also from motion picture records, is included. The stages that have been chosen are those in which (1) the right foot meets the ground; (2) the left foot [illegible] (3) the feet are approximately opposite each other; (4) the left foot meets the ground; and (5) the right foot leaves.

The transition from a quadrupedal to a bipedal method of locomotion is facilitated by the many elements that the two have in common. Among these is the similarity in the rhythm of swing of the fore-limbs. In ordinary quadrupedal walking the cycle of movement of each fore-limb is followed, after a short interval, by similar movement of the diagonally opposite hind-limb. The advantage of this arrangement for support is obvious, the necessity for lateral swaying of the body being decreased by the mating of each fore-limb with the opposite hind-limb. The slight asynchrony in their action decreases the unevenness of forward movement, as shown for the cat by Manter (1938).

In bipedal movement the fore-limb is no longer occupied with support against gravity or with acceleration of the body, but is primarily concerned with the rotation that the body undergoes, as was demonstrated for human walking by Elftman (1939c). In spite of this new function, the timing of the swing is approximately the same, since the forward swing of the arm must contribute angular momentum to neutralize partially that of the advancing leg of the opposite side.

The swinging of the arms of the chimpanzee in walking is greater in amplitude than it is in man. This is accounted for chiefly by the fact that the chimpanzee plants its feet farther apart, increasing the amount of vertical rotation that accompanies each step. The general pattern of the swinging of the arms of the chimpanzee follows that of man, but deviations are frequent, especially when irregularities of gait are occasioned by unevenness of terrain or by distraction.

In quadrupedal walking, the ground reaction is distributed through four limbs, instead of two. As each limb makes contact with the ground, it experiences a backward push, which not only retards the limb, but is, in part, communicated to the rest of the body. This is succeeded by a forward force, which restores the forward velocity of the body and starts the forward swing of the limb. In the cat, Manter (1938) has shown that the ground reaction on the fore-limbs is greater than on the hind-limbs. In bipedal walking the entire ground reaction is exerted through one pair of limbs, but it still has the same general character.

There is first a backward and then a forward force, combined with a vertical force that supports the body against gravity and is coordinated with the rise and fall experienced by the body in all types of progression.

The sequence of changes in angulation of the hind-limb is essentially similar in quadrupedal and bipedal walking. After the foot has gained contact with the

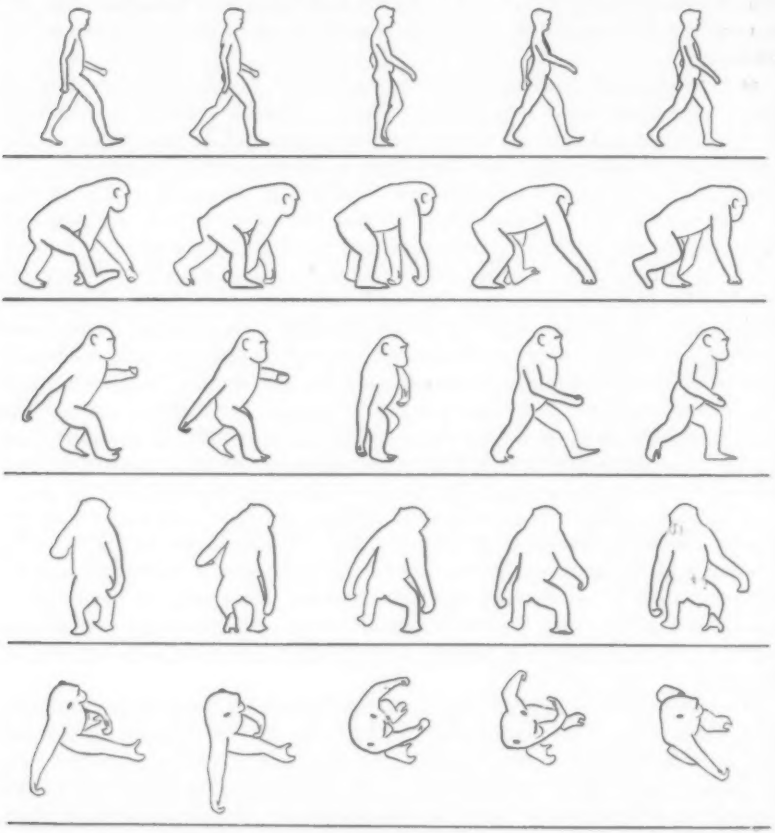

FIG. 1. Successive stages in the walking step of man and the chimpanzee, traced from motion picture records.

ground, the knee flexes, accompanied by flexion of the ankle. The knee then extends, earlier in man than in the chimpanzee, but the ankle continues to flex. Finally the ankle extends, with, eventually, flexion of the knee and of the hip.

A fundamental general requirement for bodily movement is a situation of the center of gravity of the body as a whole such that it can be supported by the limbs that gain contact with the ground. This does not mean that the center of

gravity must be continuously above the base of support, but its average position must be so located. With four limbs to call upon, this provides no serious difficulty. In bipedal walking, the problem does become serious, and an appropriate solution is necessary for successful bipedism.

One advantageous condition for bipedal support is broad foot contact. The chimpanzee, by its plantigrade habits, possesses part of this advantage. Man is benefitted further by having forsaken the arboreal adaptation of his toes, gaining the possibility of using the ball of the foot for support. This is especially important in the final propulsive thrust of the calf muscles, used in walking chiefly for propelling the leg forward, in running also for propulsion of the body. In the chimpanzee, the lack of this firmness in the anterior pillar of the longitudinal arch is compensated, to a certain extent, by the greater mobility of the mid-tarsal joint. As Elftman and Manter (1935a, b) have shown, the character of the movement in this joint is essentially similar in man and the chimpanzee, but the amplitude of movement is greater in the chimpanzee. This allows the heel to be lifted before the cuboid leaves the ground. An associated fact is the small size of the triceps surae in the chimpanzee. In an adult specimen recently dissected, the gastrocnemius and soleus together constitute 7 percent of the hind-limb musculature, while in man they aggregate 11 percent, according to the data of Frohse and Fränkel (1913).

The most important human adaptation for supporting the body on two legs, both in walking and in standing, is the association of a vertical position of the trunk with a vertical position of the femur and the tibia. For standing with minimum muscular effort, this entire combination is necessary, but for bipedal walking the requirements are somewhat less strict. For this purpose only a readjustment of the center of gravity of the body so that it can oscillate above the support afforded by the feet is necessary. This the chimpanzee accomplishes by rotating the pelvis until the trunk approaches the vertical. Without the development of a pronounced lumbar curvature, this precludes a vertical position for the femur. The inclined position of the femur is responsible for some of the characteristic differences between chimpanzee and human bipedal walking.

The contrast between the human and the chimpanzee step is most marked during the phase in which only one foot is on the ground, extending from the second to the fourth stages of figure 1. As the left foot leaves the ground, the center of gravity of the body is still behind the supporting right foot. This would be an untenable position for standing, since gravity would pull the body down backwards. In walking, however, the body has a forward velocity that, meeting the resistance of the ground acting on the right foot, provides a force that counteracts gravity and moves the body forward. In doing this the body loses forward velocity and with it kinetic energy. In the chimpanzee this energy is used up by stretching of extensors of the hip, knee, and ankle. These muscles transform the energy into heat and it is consequently lost to the body.

In man, however, the more nearly vertical position of the femur and the greater total length of the leg make it possible for the energy derived from the slowing of the body to be applied to useful purpose. With extending knee, the

body vaults upward, assisted by the shortening of the hip and knee extensors, until it attains the position of the third stage of figure 1. The body then pivots forward, allowing its decreasing elevation to increase its forward velocity, providing also excess energy which is taken up by stretching of the hip and knee flexors and ankle extensors (Elftman 1939a, b).

In the chimpanzee, the flexion of the knee continues longer than it does in man, a characteristic common to its bipedal and quadrupedal gaits. After the left foot leaves the ground, the body consequently continues to fall, reaching its lowest elevation at stage 3 of figure 1. The decrease in elevation is accentuated by the simultaneous lateral inclination of the body. The chimpanzee must consequently set about restoring the elevation of the body while it is also increasing its forward velocity, the energy coming from muscular sources, notably the hip extensors.

The importance of the knee extensors in man is reflected in their weight. In the bodies investigated by Frohse and Fränkel (1913) the muscles that extend the knee constituted 25 percent of the total hind-limb musculature. In an adult chimpanzee recently dissected, the knee extensors constituted only 16 percent. The flexors of the knee show a reverse relationship, those of the chimpanzee constituting 24 percent, those of man 21 percent, of the total hind-limb musculature.

During the final part of the step, before the foot leaves the ground, the leg must gain forward velocity. This is accomplished in man by powerful shortening of the ankle extensors and the hip flexors. In the chimpanzee, the force of contraction of the ankle extensors is not so great as in man, a fact that is correlated with the relatively small size of the triceps surae, previously mentioned. The tension exerted in man is partly necessitated by the weight and length of the limb, the human hind-limb having a weight nearly one-fifth that of the body, compared to one-eighth for the chimpanzee. Although the greater length of the human leg increases the force necessary to start its rotation, since it increases the moment of inertia, it is a fundamental asset. The greater length of step, which it makes possible, decreases the number of oscillations that must be accomplished to cover a given distance, and this results in energy-saving.

SUMMARY

A comparison of quadrupedal and bipedal walking reveals many features common to both, facilitating transition from one to the other. A fundamental difference exists in that bipedal walking requires the center of gravity of the body to be so located that its average position is above the base of support offered by the feet. Being already equipped with a plantigrade foot, the chimpanzee accomplishes the necessary change by decreasing the inclination of the trunk, the femur remaining inclined. In man, the association of an erect trunk with an erect femur allows him to manage his kinetic and potential energies so as to decrease the amount of muscular work. The greater length of leg, allowing fewer steps to cover a given distance, also results in saving of energy.

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A NEW CRANIOMETER FOR CARNIVORE AND OTHER MAMMALIAN CRANIA

BY B. ELIZABETH HORNER

It is the author's purpose in this paper to describe an instrument that she has developed and found useful in making certain craniometrical determinations on carnivore crania. [Following the suggestion of Buxton and Morant (1933, p. 20), the *skull* is here defined as the complete bony framework of the head exclusive of the hyoid bones. The *cranium* is regarded as the skull without the lower jaw.] The craniometer introduced here may be employed for the determination of cranial planes and for both the determination and the marking of certain cranial landmarks defined as being within those planes.

Because of the present lack of a standardized craniometrical technique, a large percentage of published craniometrical records are not truly comparable with those of other investigators. In an attempt to prevent in the future the vast amount of wasted labor, which this lack of standardization has caused in the past, the author is working out a proposed system for the standardization of craniometrical determinations and expects soon to publish a description of that system. As a part of the standard orientation method prerequisite to the system, the described craniometer has been evolved. Although the writer's instrument has been designed especially for work on mink crania, it may readily be adapted to the measurement either of other carnivore crania or of the crania of other mammalian orders.

For his generous guidance and invaluable criticisms throughout the progress of this work the author is grateful to Dr. Ernest C. Driver. To Mr. Russell F. Douglas, former technician in the Smith College Department of Physics, the writer is indebted for construction of the craniometer and also for numerous practical suggestions pertaining thereto.

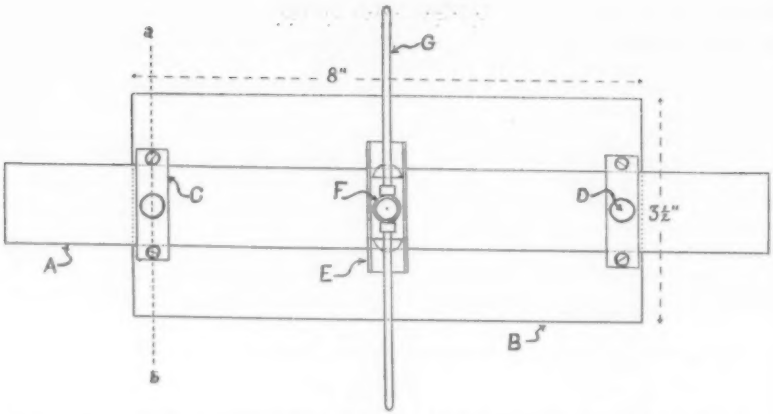

FIG. 1. Scale drawing showing base of opisthio-incisionic craniometer with side pieces and trolleys removed. A, Bar which can be moved along its longitudinal axis. B, Base of instrument. C, Arch embracing bar A. D, Thumb screw for locking bar A into position. E, Arch bridging bar A and carrying pencil-conveying apparatus. F, Telescoping tube carrying pencil. G, Handle for manipulating pencil-conveying apparatus.

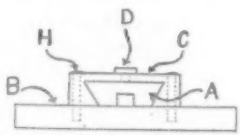

FIG. 2. Scale drawing showing cross-section through line a–b (fig. 1). H, Screw fastening arch C to base B. Other abbreviations as before.

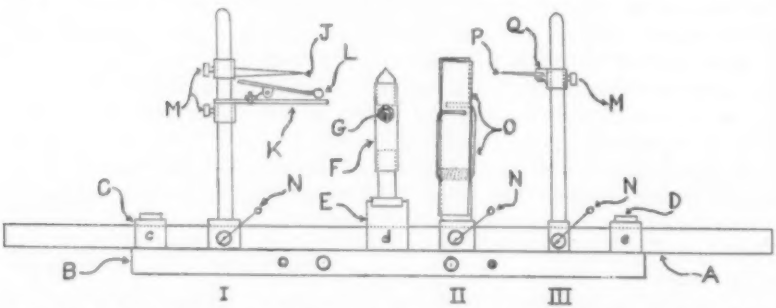

FIG. 3. Scale drawing showing lateral view of instrument with side pieces and top removed. I, Trolley bearing opisthionic pointer and clamp for posterior region of cranium. II, Trolley bearing clamp for muzzle of cranium. III, Trolley bearing the two incisionic pointers. J, Opisthionic pointer. K, Plate to which clamp L is attached. L, Clamp for locking posterior base of cranium to plate K. M, Thumb screw. N, Set screw. O, Clamp of the clothes pin type. P, Incisionic pointer. Q, Horizontal bar with grooved ends for reception of incisionic pointers. Other abbreviations as before.

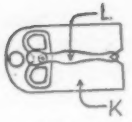

FIG. 4

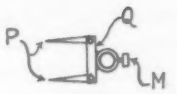

FIG. 5

FIG. 4. Scale drawing showing top view of plate K and clamp L. Abbreviations as before.

FIG. 5. Scale drawing of incisionic pointers, top view, showing their independent attachments to horizontal bar Q. Abbreviations as before.

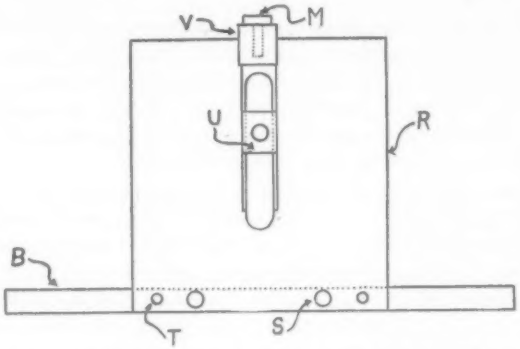

FIG. 6. Scale drawing showing side piece attachment to base and top of craniometer. R, Side piece of instrument. S, Screw attaching side R to base B. T, Dowel pin reinforcement. U, Spring and screw conveyor for vertical pointer. V, Bar connecting the two sides of the instrument and carrying upper pencil indicator. Other abbreviations as before.

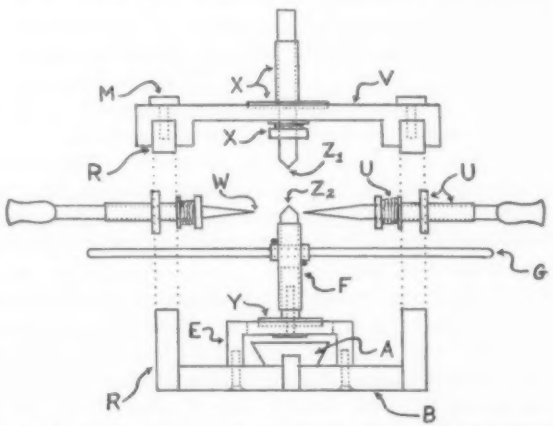

FIG. 7. Scale drawing showing structural features of a cross-section through the center of the instrument. W. Vertical pointer. X, Spring and screw conveyor for upper pencil indicator. Y, Spring and screw conveyor for lower pencil indicator. Z_1, Upper pencil indicator. Z_2, Lower pencil indicator. Other abbreviations as before.

It is proposed that the instrument here presented be called an *opisthio-incisionic craniometer*, since it is used in orienting the cranium to the *opisthio-incisionic plane*. This plane, which is the author's standard horizontal plane for carnivore crania, furnishes the basis for the standardization of many measurements. The *opisthion* may be defined as the median point of the ventro-posterior edge of the supraoccipital margin of the foramen magnum; while the *incision* is regarded as the most dorsal point of the external, as opposed to the palatal, rim of the alveolus of the most lateral incisor. The opisthion definition is modified from anthropometrical usage. The term incision, however, is an original one, together with its definition.

Important features of the instrument are three horizontal pointers, so-called because of their role in determining the standard horizontal plane to which the cranium is oriented. They are needle-pointed and adjustable for height. When the instrument is in use the pointers must each be set at precisely the same distance from the base of the instrument, thereby establishing the opisthio-incisionic plane as parallel to the base of the craniometer.

The cranium is oriented to the opisthio-incisionic plane and clamped into that position. Incorporation into the instrument of an optical bench structural feature permits the cranium to be pushed along in its horizontal orientation plane for the determination of given vertical planes, each of which is defined as being perpendicular to the standard horizontal plane and passing through a pair of bilateral cranial points. Upon location of any specified vertical plane, the two cranial points, one dorsal and one ventral, determined by the intersection of that vertical plane and the median line of the cranium, may be marked on the external aspect of the cranium by means of the two pencil indicators of the craniometer. These two points, so exactly defined and determined, constitute end points for cranial height measurement.

Details of the author's instrument, as designed for craniometrical determinations on *Mustela vison* crania, follow. With the exceptions of the pencil indicators and one clamp, it is constructed entirely of metal, the total weight being minimized by cutting the larger pieces from sheet aluminum. The accompanying drawings, supplementing the description, are drawn to scale.

Movable bar A (figs. 1, 2) is attached, in the manner of the principle of the optical bench, to the upper aspect of base B along its mid-longitudinal axis. At each end of the base an arch (C) embraces the movable bar. Loosening of thumb screw (D) allows free movement of the bar through the arch; while tightening of the screw locks the bar into place.

A pencil for marking the ventral aspect of the cranium is built onto the base of the instrument by means of arch E (figs. 1, 3, 7), which bridges bar A at the center of base B. The upper aspect of the arch is grooved and cut so that the pencil-conveying apparatus can be moved laterally. The pencil is held firmly in the end of a telescoping tube (F), which permits a given range of vertical movement. All movement of the pencil is directed by manipulation of handle (G); and it is necessary, in the interests of precision, that both ends of the handle be used in moving the pencil.

Fitted onto bar A are three separate trolleys (fig. 3) bearing all the apparatus necessary to orient the cranium to the opisthio-incisionic plane and to hold it in orientation position. Each trolley is so constructed that it may be pushed along bar A between either c and d or d and e and then locked, by means of set screw N, at any desired position.

Trolley I bears the height-adjustable and needle-sharp opisthionic pointer (J). Below this pointer is a similarly adjustable plate and clamp device for clamping the cranium into position, the clamp being of the pivot type frequently used on automatic pens and pencils. Pressure on the clamp lever raises the clamp ball; the posterior base of the cranium may then be set on the plate with the clamp ball extending into the cranial cavity through the foramen magnum and clamping the posterior end of the cranium into position as pressure on the lever is released. The ball-end clamp, coupled with the wedge-shaped cut (fig. 4) in the adjacent plate, permits a certain amount of movement of the cranium within its standard horizontal plane, a necessary consideration in view of the frequency of slight cranial asymmetry.

Trolley II carries a simple clamp (fig. 3, 0), which may be of either the clothes pin or the haemostat type. If the clamp is of the former variety, the spring tension must be released so that the clamp grasps the muzzle of the cranium firmly and securely without at the same time injuring its bony structure.

Trolley III bears the two needle-sharp incisionic pointers P (figs. 3, 5), so constructed as to be independently movable in the horizontal plane of orientation but inseparably height-adjustable.

The two sides of the instrument are identical in construction and are screw-attached to the base (figs. 6, 7). Additional dowel pin reinforcements are recommended for further stabilization of the instrument, thereby minimizing probable instrumental error. Each side is grooved and cut to carry a spring and screw device (U), which, in turn, carries a needle-sharp vertical pointer (W). The vertical pointers are so named because they are employed in the determination of vertical cranial planes; all movement of these pointers is confined to a single vertical plane of the instrument. Each pointer may be moved laterally through the spring and screw conveyor, or it may be moved vertically along with its conveyor.

Connecting the two side pieces across the top of the instrument is bar V, which carries the upper pencil indicator (fig. 7, Z_1). The bar is grooved and cut to carry a combination pencil holder and conveyor (X). The pencil is held in its container by a friction fit. It may be moved vertically through its tube container, or it may be moved laterally along with its gliding conveyor. Each end of the bar fits over the adjoining side piece of the craniometer, thumb screws fastening the bar immovably into position (figs. 6, 7). All movement of the two pencil indicators is in one and the same plane of the instrument as that of the vertical pointers.

In a precision instrument of this type the importance of perfect alignment and exact fittings cannot be overemphasized. The opisthio-incisionic plane, determined by the three horizontal pointers, must be parallel to the base of the

instrument. Any plane perpendicular to the base of the instrument is therefore automatically perpendicular to the opisthio-incisionic plane. Useful vertical craniometrical planes are each defined as passing through two bilateral cranial points and being perpendicular to the opisthio-incisionic plane. Consequently, when the vertical pointers are made to coincide with the necessary bilateral points of a properly oriented cranium, the desired vertical plane is automatically determined by the instrument. (This is true, of course, only for crania which exhibit a reasonable degree of bilateral symmetry.) Since the pencil indicators are used to mark the median line of the external aspect of the cranium in the plane determined by use of the vertical pointers, it is essential to the technique that the craniometer be calibrated at frequent intervals. If the pencil points and the points of the vertical pointers cannot be brought together to meet at a single point, the defect must be remedied before further determinations are made. A good supply of lathe-sized, -centered, and -sharpened 6H pencils should be kept available. Each pencil should be changed after 10 or 12 markings, or oftener if calibration so indicates.

In orienting the cranium and marking it for measurement the following procedure is recommended:

1. Check the opisthionic and incisionic pointers to verify their being exactly the same distance above the base of the instrument.
2. Calibrate the instrument as directed above.
3. Clamp the cranium into temporary position, dorsal side up, with its muzzle embraced by clamp O (fig. 3) and its posterior base supported by plate K, with the ball of clamp L pressing against the floor of the cranial cavity.
4. Cautiously reset the cranium if necessary so that the opisthionic and incisionic pointers can be brought just into contact with the corresponding points of the cranium, and then lock all three trolleys into position.
5. Loosen the thumb screws holding bar A in position and move the bar along until the bilateral cranial points used in defining the desired vertical plane appear to be in the plane of the vertical pointers. Bring the pointers toward the cranial landmarks, carefully manipulating bar A and the cranium until the tips of the vertical pointers coincide with the proper landmarks. Then lock bar A into position by tightening the screws.
6. By means of the pencil indicators make a mark across the median line of the cranium on both its dorsal and its ventral aspects.
7. Remove the vertical pointers and pencil indicators from the cranial surface, loosen thumb screws D, and convey the cranium to proper position for determination of the next desired vertical plane.
8. When all cranial landmarks to be indicated by use of the craniometer have been located and marked, remove the cranium from the instrument and make direct caliper measurements from the points at which the pencil marks cross the median line of the cranium.

By use of the instrument and the technique here described, precisely defined and readily repeated cranial height measurements may be obtained at any level of the cranium. A slight modification of the same instrument might also be used

for cranial width determinations, although it is the writer's opinion that most width determinations can be satisfactorily obtained by a simpler technique.

To permit photographing of the properly oriented cranium and also to facilitate any necessary adjustment of the instrument, the craniometer is so constructed that its dorsal bar and both its side pieces may readily be removed without interfering at all with the position of the cranium.

Contribution from the Department of Zoology, Smith College, no. 205.

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REMARKS ON THE SYSTEMATICS OF ELEPHANTULUS

BY C. J. VAN DER HORST

In 1909, Chubb described a subspecies of the elephant shrew found in the neighborhood of Johannesburg under the name *Elephantulus rupestris jamesoni*. This subspecies, of which extensive material could be collected, has been the subject of different papers dealing with its development and sexual cycle. Another subspecies had been described by Thomas and Schwann (1906) under the name *Elephantulus rupestris myurus*. According to Roberts (1924), however, the latter subspecies is specifically different from the original *E. rupestris* from the mountains near the mouth of the Orange River. The main and most obvious difference is that in *E. rupestris* the tail is covered with rather long hairs, whereas in *E. myurus* the hairs are short. Chubb's subspecies *jamesoni* agrees in this respect with *E. myurus* and must accordingly be considered as a subspecies of the latter, so that it is designated now as *Elephantulus myurus jamesoni*.

Previously (1906), Thomas and Schwann had divided the original genus *Macroscelides* into three genera, viz. *Macroscelides*, *Nasilio* and *Elephantulus*. The genus *Macroscelides* is characterized by the enormously swollen bullae osseae that extend to the top of the skull. *Nasilio* is distinguished by a third molar in the lower jaw, whereas *Elephantulus* has only two lower molars like *Macroscelides* and small bullae like *Nasilio*.

Only one species of *Macroscelides*, *M. proboscideus*, is known. It has a number of subspecies occurring especially in the northwestern part of the Cape Province and in the adjoining South West Africa. Also, only a single species of *Nasilio*, *N. brachyrhyncha*, is known, which ranges over the greater part of southern Africa up to the Congo. But many species of *Elephantulus* have been described, their ranges extending from the Cape to the Mediterranean.

A related genus, *Petrodromus*, was first described by Peters (1852). Its chief characteristic is the absence of the hallux; it occurs especially in East Africa.

The fifth genus of the Macroscelididae, *Rhynchocyon*, differs in several respects, especially in the absence of the upper incisors, from the other four and is therefore placed in a separate subfamily. This genus is restricted to East Africa.

Elephantulus myurus jamesoni exhibits the remarkable phenomenon that at every ovulation the enormous number of about 60 eggs are liberated from each ovary (van der Horst and Gillman, 1941). Consequently, after ovulation also about 60 corpora lutea develop in each ovary (fig. 1). Yet of all 60 eggs, only one will become implanted in the uterine wall and normally develop into a young animal. Almost invariably a gravid animal bears twins, the embryos being symmetrically placed in the two uterine horns. In not more than one percent of

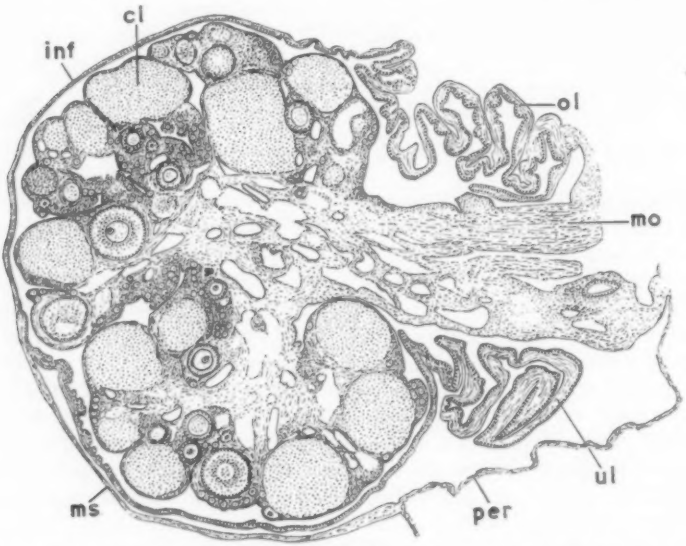

FIG. 1. A section through the ovary of *Elephantulus myurus jamesoni*, × 35. *cl*, corpus luteum; *inf*, infundibulum; *mo*, mesovarium; *ms*, mesosalpinx; *ol*, ovarian lip; *per*, peritoneum; *ul*, uterine lip.

the several hundreds of gravid uteri that could be studied was asymmetry observed; it may be that only one horn was swollen or that the swellings of the two horns showed a marked difference in size.

When material was obtained of *Elephantulus intufi* from Sekukuniland in North-Eastern Transvaal, it was noticed that the ovaries of gravid females contained only one corpus luteum. This surprising difference from *E. myurus jamesoni* induced us to collect more material of *E. intufi* and during a few days sojourn in Sekukuniland we were fortunate in obtaining nearly a hundred gravid females.

At once, another point of difference between the two species was noticed. In about half of the gravid females of *E. intufi* the uterus was found to be asym-

metrical with an embryo in only one of the two horns. When more of the ovaries of *intufi* are sectioned it may be possible to find a reason for this asymmetry. For the moment it can only be stated that this rare phenomenon in *E. myurus jamesoni* is very common in *E. intufi*.

Some of the better preserved material of *E. intufi* was serially sectioned and from it we were able to confirm that a gravid female has only one, or at most two, corporus luteum in the ovary.

Although it is not always easy to get suitable material, we succeeded in obtaining some specimens of a few other species of elephant shrews. From this it appeared that *Macroscelides proboscideus* and *Elephantulus capensis* behave as *E. myurus jamesoni*; they also have a great number of corpora lutea. On the other hand, *Petrodromus tetradactylus* and *Elephantulus rupestris* have only one corpus luteum per ovary like *E. intufi* (fig. 2). We have not yet succeeded in obtaining material of *Nasilio*, but, even without this, it is clear that two groups of species can be distinguished in the family of the Macroscelididae. In the one group a great number of eggs are liberated at each ovulation and consequently the same number of corpora lutea are formed, although only one embryo will become implanted in each uterine horn. In the other group, the number of liberated eggs and that of the corpora lutea is only one or two.

The total amount of lutein tissue, however, differs not so much as might be expected from the difference in number of corpora lutea. The rather regularly shaped corpus luteum of *Elephantulus rupestris* (fig. 2) has a volume of about 0.9 mm^3. In *Elephantulus myurus jamesoni* the average diameter of regularly formed corpora lutea was found to be 7/20 mm, so the volume of one corpus is 0.02245 mm^3. As there are about 60 corpora lutea in an ovary, the total amount of lutein tissue in one ovary is 1.347 mm^3. Judging from the single specimen of *Elephantulus rupestris* available, this species is of the same size as *E. myurus jamesoni*. Also Sclater (1901) giving the measurements of *E.* (*Macroscelides*) *rupestris* says that an example from near Johannesburg, obviously *E. myurus jamesoni*, is in close agreement with these measurements. In this respect it has to be remembered that in *E. intufi* there are often two corpora lutea in one ovary and this might also be the case in *E. rupestris*, although in the single specimen there was only one. If three corpora lutea were present in the two ovaries of *E. rupestris*, the total amount of lutein tissue would be the same as in *E. myurus jamesoni*.

Another fact may be of importance in connection with this possible difference in the amount of lutein tissue. As previously mentioned, *E. myurus jamesoni* always has two embryos, one in each uterine horn. *E. intufi*, on the other hand, carries two embryos in only about 50 percent of the cases; otherwise, there is only one. The single specimen of *E. rupestris* had one embryo only. Shortridge (1934) found among four gravid females of the same species three with two embryos and one with a single one. There is a possibility that the variation in the number of embryos has some relation to the amount of lutein tissue. If this is so, *Nasilio brachyrhyncha* would also have one or two corpora lutea per ovary. But this is a question that needs further investigation and it can only be solved by the study of extensive material.

Related to the size of the corpora lutea is another difference between these species that makes it possible to differentiate between them even if there are no

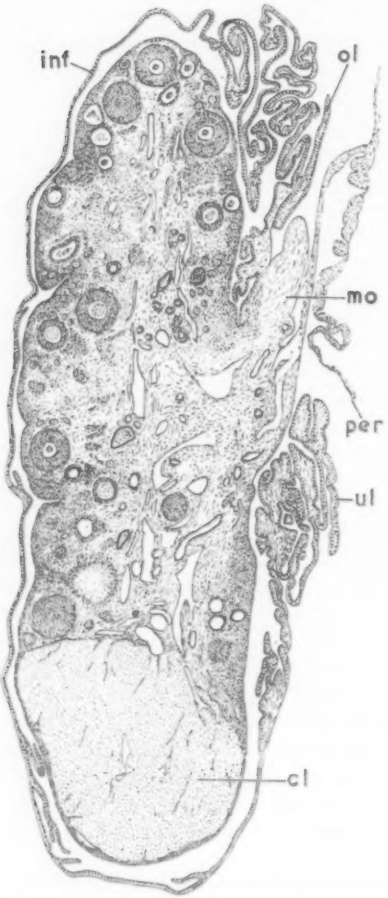

Fig. 2

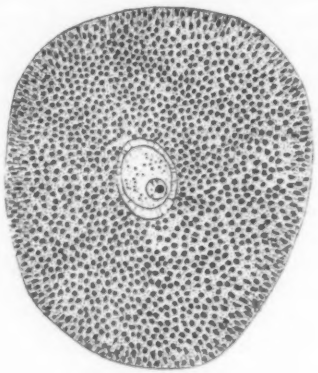

Fig. 3

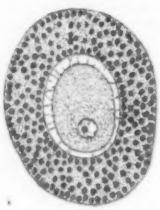

Fig. 4

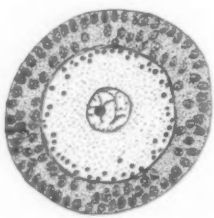

Fig. 5

Fig. 2. A section through the ovary of *Elephantulus rupestris*, × 35. *cl*, corpus luteum; *inf*, infundibulum; *mo*, mesovarium; *ol*, ovarian lip; *per*, peritoneum; *ul*, uterine lip.
Fig. 3. A multilayered Graafian follicle of *Elephantulus intufi*, × 150.
Fig. 4. A multilayered Graafian follicle of *Elephantulus myurus jamesoni*, × 150.
Fig. 5. A young follicle of *Elephantulus intufi*, × 250.

corpora lutea at all. It is obvious that the size of the corpus luteum must stand in close relation to that of the Graafian follicle. Figures 3 and 4 show the follicles of *E. intufi* and *E. myurus jamesoni* just prior to the appearance of fluid

in them. The difference in size and in the number of follicular cells is very marked. The follicle of *E. intufi* is of the type found in most mammals, but that of *E. myurus jamesoni* is remarkably small. Between an inner layer of cells that will constitute the corona radiata and a rather regular peripheral layer there are only a few scattered nuclei, whereas in *E. intufi* the whole follicle is densely crowded with nuclei.

There exists, however, another difference between these two species and this does not seem to be related to the size or number of the corpora lutea. In the ova of many mammals fat-globules are found. Hill (1932) observed these globules in the eggs of *Loris* and *Tarsius*, but in the higher Primates, including man, they are absent. The presence or absence of fat-globules is a remarkable point of distinction between the different species of the Macroscelididae. Very clear fat-globules are found in all eggs of *E. intufi*. In the young oöcytes (fig. 5) they occupy a position along the periphery of the egg, but later on they become scattered throughout the substance of the ovum. At any stage they form a conspicuous feature in the eggs of *E. intufi*. On the other hand, in the ova of *E. myurus jamesoni* there is not a trace of fat-globules at any stage of their development—a normal healthy egg has a finely granular appearance. Concerning other species, it can be said that fat-globules are present in *Elephantulus rupestris* and absent in *Macroscelides proboscideus*. In *Elephantulus capensis* they are present, but few in number. The available material of *Petrodromus* shows only that the substance of the egg is not homogeneous, but it can not be determined whether fat-globules are present.

It is beyond doubt that the chemical constitution of the egg is different in species that according to the systematists belong to one and the same genus. Likewise, the size of the corpora lutea and of the Graafian follicles and the number of eggs liberated at ovulation and that of the corpora lutea formed after ovulation exhibit a marked and fundamental distinction between these species. What the cause of this difference may be is for the moment unknown; there may be a simple reason why *Elephantulus myurus jamesoni*, *E. capensis* and *Macroscelides proboscideus* can be so wasteful with their ova, whereas *Elephantulus intufi*, *E. rupestris* and *Petrodromus tetradactylus* are as conservative in this respect as other mammals.

It can not be expected that systematists base the differentiation of species and genera on the histological appearance of the ovary; they have to rely on characters that are more easily visible. Yet, on the ground of the histological picture of the ovary, as far as this is shown by the few species studied, one may conclude that there are only two genera of Macroscelididae (*Rhynchocyon* not being taken into account) and that the division between them cuts across those separating the four genera recognized by systematists.

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FURTHER CONSIDERATION OF AMERICAN HOUSE MICE

BY DAVID G. NICHOLS

The recent taxonomic review of the house mouse, *Mus musculus*, by Schwarz and Schwarz (1943) gives an excellent working nomenclature for that group, which has hitherto been in a confused state. In the course of several years' studies on the American development of *Mus*, I have obtained some data that lead me to doubt that the American animals similar to *brevirostris* and *spicelegus* were introduced from Europe as such. Experiments of trapping and breeding feral *Mus*, carried on by Frank G. Watson and the author, unfortunately were terminated by the war before publishable results could be obtained. However, certain comments on the present status of American *Mus*, based on examination of material collected since the writing of my last brief reports on this problem (Nichols, 1938, 1939), seem of sufficient interest to publish.

Mus is distributed over the entire United States. With the exception of high mountain regions, it is found in the feral and commensal state wherever it occurs. It becomes very abundant where living conditions are favorable. Centers of abundance appear commensally in cities and ferally in rural localities. Both rural and urban centers of abundance appear as colonies to the collector and are hereinafter referred to as such. The broad picture of distribution in the United States may be represented, therefore, as moderately abundant throughout, with colonies cropping up wherever conditions are favorable. Feral colonies are not found frequently in the Northern States and a comparatively uniform sparse distribution results. On the other hand, in the agricultural belt from the Mississippi to the Atlantic just north of the Gulf of Mexico, colonies are so numerous and well developed that the opposite condition of uniform, dense distribution obtains, the colonies merging into one another. In the West, colonies are found here and there wherever conditions are favorable and, in keeping with the broken terrain, are often widely or effectively separated by geographic barriers.

Practically all the colonies I have trapped can be distinguished from one another by some external feature: pelage color and pattern, length of ear, ratio of tail to head and body. They are also distinguishable by differences in odor

and temperament in captivity. Mr. H. C. Raven called my attention to the fact that skins of commensal *Rattus* taken in Borneo dried out more "crackly" (presumably thicker-skinned) than the specimens of feral animals taken in the same vicinity. He demonstrated this difference to me in a series of feral and commensal *Mus* from the Cape Charles Peninsula, Virginia. Most authors handling live stock have noticed the difference in odor between commensal and feral *Mus*, which difference is marked in American colonies. Temperamental differences are strongly individual, but they seem to have general distinctive tendencies in different colonies.

When a colony of *Mus* is trapped, a cross-section view of the development of that group at a given moment is obtained. Although this *static* view is unsatisfactory in studying a highly fluid and *dynamic* situation, nevertheless, results thus obtained are interesting and suggestive. The American colonies, which differ measurably from one another and from European groups, usually clearly manifest development along one of the three definite patterns described below.

(1) *Percentage of Mutants.*—The colony contains a certain number of individuals sharply distinguished from all others of the same colony. For example, a collection of animals from Folly Beach, near Charleston, South Carolina, contained 3 silver animals (similar in appearance to the Chinchilla mutation—Keeler 1931 p. 22), 1 "yellow" (similar to the non-agouti (a)—Keeler 1931 p. 24), 3 darker than *M. m. domesticus* (with high development of melanin), and 34 light bi-colored animals similar to *M. m. brevirostris.*

(2) *Total population of mutants.*—The entire population of the colony is markedly different from the surrounding populations or from the population from which the colony may be supposed to have been derived. A good example of this is the *M. m. jalapae*, a black race described from Jalapa, Mexico, by Chapman. The entire collection of animals is jet black and comparable (with some slight differences) to jet black populations found in the orient and with melanistic individuals found elsewhere (particularly in Southern France).

(3) *Slight average difference.*—The entire population of the colony presents a slight average difference from contiguous and nearby populations or from presumed parent populations. For example, a collection of 13 animals from Grizzly Island, Suisun Bay, Solano Co., California, made by J. C. von Bloeker and now in the Los Angeles Museum of History, Science and Art, are noticeably darker than typical *domesticus* although their measurements conform closely to the average of this race.

This divergence of colonies from the normal is a strong characteristic of *Mus musculus.* A detailed consideration of numerous American colonies does not destroy the general north-south pattern, i.e. the tendency toward *brevirostris* in the South and toward *domesticus* in the North, which has been noted by Harper (1930), Nichols (1939) and Schwarz (1943).

However, the present author does not think that independent introductions of *brevirostris* in the South, from Spain, and of *domesticus* in the North, from England, is a satisfactory and complete explanation of the situation. Assuming that our rural population of *Mus* was largely developed from commercial centers (where *domesticus* is always found abundantly), there is reason to believe that

a part of our rural population in the South represents a reversion of *domesticus* to the wild type. Such a reversion would be indistinguishable from *brevirostris* except, perhaps, with the aid of breeding experiments. The apparent facility with which *Mus* develops morphologically distinguishable colonies even in urban localities lends further weight to the reversion theory. In any event, it should be emphatically stated that the dynamic relationship of the *Mus* colony to the entire population is not well understood. As this is a biological problem of considerable theoretical interest and importance, it is hoped that it will not be neglected by American mammalogists.

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GENERAL NOTES

A CRITICISM OF MARSHALL'S METHOD FOR CENSUSING MINK

Marshall (Jour. Mamm. vol. 17, no. 4, pp. 382–392) has proposed a census technique for determining mink populations based upon measurements of tracks of the hind feet in fresh snow. This method involves the assumption that the lengths of the hind feet of the males and females fall into two distinct groups that are clearly separable upon the basis of measurements. Since the population estimate is based upon the female territories found in a unit area, it is essential that the tracks of males and females be distinguishable from each other to render the census technique valid.

During the trapping seasons of 1940 and 1941, the writer measured a total of 154 hind feet of both sexes of mink on carcasses that were procured from southern Michigan fur-buyers. A total of 91 males were measured. The mean hind foot length of this group was 59.7 millimeters with a standard deviation of 3.9 millimeters. Sixty-one females were measured and the mean hind foot length of this group was 50.1 millimeters with a standard deviation of 2.2 millimeters. As Marshall has stated, there is a significant difference in the means of the two groups but the distinct overlap in the distributions of male and female measurements is ignored.

Figure 1 shows the distribution of the actual measurements of the length of hind foot in males and females. It is obvious by inspection that a fairly broad region of overlap exists in the two series of measurements. An animal with a foot length falling within the region of overlap cannot be identified with certainty as to sex by foot length alone. A measurement falling in the upper range of the overlap will have a greater chance of being a male than of being a female. The reverse is true in the lower range of the overlap.

Figure 2 is a generalized statement of this relationship, which was derived from the two

original frequency distributions in the following manner. Each of the original distributions was graduated according to the normal curve, using the mean and standard deviation

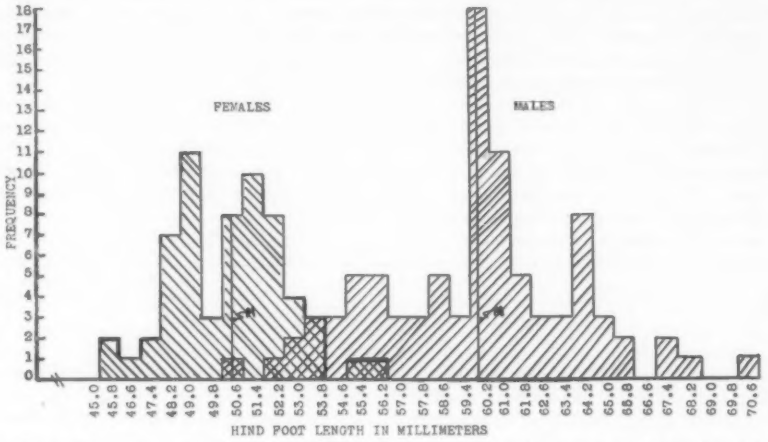

FIG. 1. Frequency distribution of hind foot measurements of 61 female and 93 male mink.

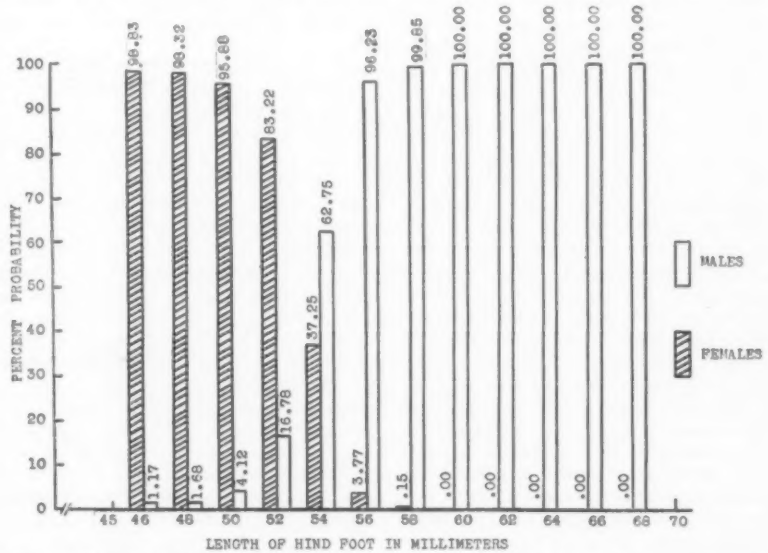

FIG. 2. Graph showing the comparative chances that an animal at a given measurement has of being a male or female.

and a table of ordinates of the normal curve in a manner outlined in many statistics textbooks. From the graduated curve for the male data, the proportion of males expected to occur with a particular foot length may be determined, and in a similar manner the propor-

tion of females expected with this same foot length. In figure 2 the male or female representation in the total at any of the selected points is given as a percentage of that total.

As an example, a foot length of 54 millimeters lies 1.47 t-units from the mean of the male data and 1.79 t-units from the mean of the female data. A table of ordinates of the normal curve gives a value of .1348 for the height of the male curve and .0801 for the height of the female curve at 54 millimeters. Hence the males should comprise 62.8 percent and the females 37.3 percent of the animals with this foot length.

Since the census technique that Marshall has proposed is based largely upon the accurate determination of female tracks in the field, it appears that the method is subject to a considerable margin of error because of the definite possibility that any measurement falling into the region of overlapping distributions of the two sexes might be misidentified in the field. Therefore, if Marshall's census method is followed a great deal of caution must necessarily be exercised in the interpretation of the resulting data.

Acknowledgement is made to Mr. D. W. Hayne, Michigan State College, for aid with the statistical treatment of the data.—John A. Sealander, *Detroit Lakes, Minnesota.*

A COMPARISON OF OVERWINTERING POPULATIONS OF SMALL MAMMALS IN A NORTHERN CONIFEROUS FOREST FOR TWO CONSECUTIVE YEARS

During April and May, 1941 and 1942, rather extensive trapping operations were carried out on the Forest Experiment Station of the University of Minnesota in the northeastern part of the state. The area provides the principal ecological types of the region and representatives of each were trapped systematically. The types include mature upland forests of Norway pine (*Pinus resinosa*), jack pine (*Pinus Banksiana*), aspen (*Populus tremuloides*), and paper birch (*Betula papyrifera*), as well as tamarack (*Larix laricina*), black spruce (*Picea marina*), balsam (*Abies balsamea*), and white cedar (*Thuja occidentalis*) swamps. Also included are transitional zones between swamp and upland and grass and sedge meadows bordering small streams and swamps.

Although the trapping records for 1942 are not so extensive as those for 1941, enough were obtained to allow a comparison of the populations for the two years. The areas trapped were selected according to type and in 1941 sixteen trapping areas were used. In 1942, however, it was not deemed necessary to use all 16 stations since several are in identical types and therefore only 8 of them were trapped again. The traps were set more or less at random and no particular pattern was followed. For the most part, however, they were approximately 10 paces apart in irregular lines. Except for occasional overlapping, the trap line in 1942 did not cover the same territory as that of 1941. This arrangement, it seems, would reduce the possibility of the 1941 trapping influencing the 1942 populations.

The results obtained indicate a considerable difference in the total overwintering populations for the two years. In 1941, a total of 234 small mammals were taken in 7254 trap nights (31 trap nights per animal) while only 75 were taken in 3946 trap nights in 1942 (52.61 trap nights per animal). The actual numbers of each species taken are shown in Table 1. Although both *Zapus* and *Napaeozapus* were taken, they are excluded because they were still in hibernation during much of the trapping periods.

With the exception of *Eutamias*, each species was taken more often in 1941 than in 1942. The two species of shrews represented show only a slight decrease from 1941 to 1942 and these differences are too small to be significant. *Peromyscus*, *Clethrionomys*, and *Tamias* each decreased more than 50 percent. Sixteen *Microtus* and two *Glaucomys* were taken in 1941 while none was taken in 1942. In the case of *Microtus* this indicates a considerable decline but too few *Glaucomys* were taken to justify any conclusion.

Peromyscus was taken quite commonly in 1941 (exceeded only by *Clethrionomys* and *Sorex cinereus* in total numbers caught), particularly in the more open uplands, while in 1942 it was much less abundant and three of the six taken were in coniferous swamps. In 1941, *Clethrionomys* was caught more often than any other species and my records show, as has been pointed out by Hatfield (Jour. Mamm., vol. 19, pp. 207–211, 1938), that this species is most frequent along the borders of swamps. During 1941, however, it was by no means

restricted thereto as it was taken in considerable numbers in uplands. In fact, every ecologic type yielded at least one specimen. In 1942, none was taken in the uplands.

On the other hand, *Sorex cinereus*, a species that prefers swamps to uplands, showed no appreciable decline in population in 1942 over 1941. This fact, coupled with the decline of *Clethrionomys*, made it the most common small mammal for 1942 in the areas trapped. *Sorex arcticus* also maintained approximately the same population for the two years.

The respective populations of the two chipmunks *Eutamias* and *Tamias* for the two years present contrasting pictures. *Eutamias*, which I have taken most often in swamps (of the 18 caught in 1941, 12 were in swamps—in 1942, 8 of 11 were in swamps), was more abundant in 1942 than in 1941, while *Tamias*, which according to my records is more of an upland species (of the 12 caught in 1941, 10 were in uplands—in 1942, all three taken were in uplands), was less abundant in 1942.

In general, the species and individuals preferring swamps were able to maintain approximately the same populations for the two years whereas those preferring the more open uplands decreased considerably. Weather conditions influence overwintering success of many species of wildlife in this area and probably explain the differential in overwintering that my trapping records indicate. During the winter 1940–41 there was considerable snow (71.6 inches from November to March) while in the same months of the following winter

TABLE 1.—*Two year trapping record of small mammals on Cloquet Forest Experiment Station*

SPECIES	1941 CATCH	1942 CATCH	NUMBER PER 3000 TRAP NIGHTS		% CHANGE PER 3000 TRAP NIGHTS
			1941	1942	
All species	234	75	96.77	57.04	−41.07%
Clethrionomys gapperi gapperi	83	18	34.32	13.68	−60.14%
Sorex cinereus cinereus	63	34	26.05	25.84	−00.81%
Peromyscus maniculatus gracilis	34	6	14.06	4.55	−67.64%
Microtus pennsylvanicus pennsylvanicus	16	0	6.61	0	−100.00%
Eutamias minimus jacksoni	18	11	7.44	8.36	+12.36%
Tamias striatus griseus	12	3	4.96	2.28	−54.04%
Sorex arcticus laricorum	6	3	2.48	2.28	−7.26%
Glaucomys sabrinus sabrinus	2	0	.82	0	−100.00%

there were only 34.7 inches of which more than half, 19.1 inches, fell in March. Save for the swamps, much of the area was devoid of snow or nearly so during some of the most severe weather in the winter of 1941–42 while in 1940–1941 this was not the case. This suggests that the lack of snow cover during the winter 1941–1942 is responsible, at least in part, for the drop in populations of the more upland species. This conclusion is supported by the fact that the swamp species, which had the benefit of better protection afforded by ground cover, lower canopy of the dominant vegetation, and greater accumulations of snow, did not decrease.—DON C. QUIMBY, *University of Minnesota, St. Paul, Minnesota.*

SPECIFIC DIFFERENCES IN THE CALL NOTES OF CHIPMUNKS

The many species of chipmunks that occur in California are segregated zonally and ecologically so that two kinds ordinarily are not present at the same locality. Nonetheless, because of interdigitation of habitats, one may find different species in close proximity and even occasionally about the same trees or bushes. How do such animals when thrown together recognize their own kind and how may a field naturalist distinguish them other than by collecting? The markings of several of our Californian species are similar in high degree and in view of seasonal and age differences in pelage and size rarely can an observer be assured of his sight identifications. Small differences in markings, odors, and

behavior patterns conceivably could operate at close range to guide the conduct of a chipmunk in such a way as to control mating at least and thus isolate species from each other. In a diurnal mammal of this sort that makes frequent use of vocal utterances, we may suspect that differences in call notes exist, which, as with birds, serve as releasers of instincts and so may coordinate activities and effect species recognition.

The notes of chipmunks appear to have received little attention in the literature. On first acquaintance they do not impress one with their diversity as do the songs of many birds. So far as I am aware, the principal attempt to describe the notes of Californian species is that of Grinnell and Storer (1924, pp. 177–195). Their descriptions are not for the most part comparative and the phonetic renditions for any one species could probably apply equally well to several species. It is apparent, however, that the small *Eutamias alpinus* possesses a distinctively high-pitched and weak note and it is suggested that *Eutamias quadrimaculatus* has a sharper call note than *Eutamias speciosus frater*.

Grinnell and Storer's descriptions, supplemented by my own field experience with most of the species they discuss, lead me to classify the notes of chipmunks generally into three categories: (1) a low-pitched, resonant bark, represented as *bŏck*, uttered usually at regular and fairly long intervals. (2) High-pitched chipping notes, given more rapidly than the bark, and not so definitely rhythmic. These may be represented variously as *whisk*, *whsst*, or *psst* with variations that have downward inflections and others that are two-parted. These are the notes given immediately upon alarm, as when a person squeaks; later the chipmunk may shift to the bark. (3) A jumble of notes, often a mixture of guttural and wiry types, given when running to cover or when closely pursued. In line with experience with other animals we would expect these three basic types to be subdivisable upon further concentrated study in the field where an effort was made to understand their precise meaning in the economy of the animal; new and less conspicuous notes might also be found.

As contributing to our knowledge of specific differences in notes, I relate my recent experience with *Eutamias sonomae* and *Eutamias townsendii siskiyou* in Trinity County in August and September of 1942. These two species are ecologically and zonally separated as Grinnell (1915, p. 324) and Johnson (in press) have described. My observations correspond in general with theirs. On South Fork Mountain, at 5000 to 5500 feet, *E. sonomae* was found only along ridges, in exposed, hence warm, tracts of brush of several hundred yards extent. The constituent plants were *Ceanothus cordulatus*, *Prunus*, *Amelanchier* and *Garrya*. *Eutamias townsendii* was in the surrounding fir forest, which was high Transition or even Canadian in character. The forest trees were white and red fir, with some incense cedar and Douglas fir marginally. The Townsend chipmunks were active in the downed logs of the forest floor but ranged into bushes of *Ceanothus cordulatus* at the edge of the forest where they actually met *Eutamias sonomae*.

For several days our party worked through the brushy openings and forest at this locality, repeatedly verifying the ecologic preferences of these two species by collecting them. Soon I became aware of correlated differences in sounds and shot a number of animals while they were giving the high-pitched chipping notes (type 2). The chipmunks were identified at once in hand by the difference in ear pattern, which is readily seen in summer pelages (see Johnson). The following is my impression of their notes written at the time (August 30): "The response [of *sonomae*] to [my] squeaking was rare. Only twice [today] did I get the excited bark comparable to *E. townsendi* and never did a running one stop for a squeak. A few were heard at a distance giving the mellow, low 'pok' note common to chipmunks. When an excited bark [type 2] was given, it was remarkably different from that of *townsendi*. Instead of being quick and shrill, as in most chipmunks I know [including *townsendi*], it is labored, blunt and sounds almost like a fox sparrow. The closest approach is to the call of a very hungry young junco. . . . There may be only 3 to 5 notes in the series. This was the note of full grown animals. The distinction in this note of these species is as easy to make out as that between the notes of *Penthestes gambeli* and *rufescens*."

Later at Carlotta, Humboldt County, and at a point 8 miles northeast of Hyampom, Trinity County, the differences in notes and habitat were verified. *Sonomae* seemed more phlegmatic in its response to squeaks, but when it did respond, the sounds were less sharp, that is, lower pitched, and more slowly repeated than in *townsendii*. Having established the reliability of this field character in widely separated populations, we found it possible quickly to survey the disposition, ecologically, of these kinds of chipmunks in a new locality with every reasonable assurance of accuracy.

Perhaps *sonomae* is unusually distinctive in its notes, but I am encouraged to believe that close attention to notes of other chipmunks may bring to focus other helpful differences in the sounds they produce. Assuredly the chipmunks must also have some awareness of these differences.

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ALDEN H. MILLER, *Museum of Vertebrate Zoology, Berkeley, California.*

ABUNDANCE OF HOUSE MICE AT DAVIS, CALIFORNIA, IN 1941–42

An unusual increase in the house mouse (*Mus musculus*) was noted at Davis in 1926 (Storer, Jour. Mamm., vol. 12, pp. 316–317, 1931), coincident with a mass irruption in the dry basin of Buena Vista Lake, Kern County, California, (Hall, Univ. Calif. Publ. Zool. vol. 30, pp. 189–203, 1927). These localities are about 270 miles apart, in the great central valley of California. No other instances of unusual numbers of house mice in the valley have come to our attention until the autumn of 1941 when the species again became very abundant at Davis. Conditions that may have favored the latter increase were a wet spring followed by presence of green vegetation later than usual in the summer. About mid-September, house mice came to notice in numbers, and by the end of October were present in "plague" proportions in farm buildings. The peak of the population was probably reached in November; large numbers continued on into February, when decline set in.

There was also indication that house mice living in fields and meadows likewise increased in numbers. Thus, in January, attempts to trap meadow mice in their occupied runways on the levee of Putah Canal (a mile south of the campus) were continually thwarted because house mice entered the traps; on January 21 and 23 seven and nine house mice respectively were taken in ten traps set in such runways.

The 200 mice captured from January 8 to March 10 included 81 males and 119 females, a sex ratio of 68 males per 100 females. Of the males, 60 weighed 15 grams or more (22.5 grams) and 54 had enlarged testes; males apparently able to breed were captured as early as January 8. Among the females only 7 had the vagina perforate; none was pregnant and only 9 young mice (10 grams or less) were taken in the nine weeks. The latter facts suggest that breeding was far reduced but not entirely suspended during the winter. These findings parallel those by Baker (Proc. Zool. Soc. London, 1930, pt. 1, pp. 113–124) regarding British *Apodemus* whose breeding season appears to be regulated by the reproductive condition of the females. The situation in respect to breeding observed in house mice at Davis may be normal for the species in this part of the country, or may apply only to a population following sudden increase.

The color of the pelage of the 200 individuals showed certain variations. Two specimens had a small but distinct patch of white hairs on the belly, and two others had a similar patch on the crown. Fifty were definitely bicolored, with whitish or creamy buff bellies, a type of coloration previously reported for house mice in California by Dice (Science, vol. 35, pp. 834–836, 1912) and Nichols (Jour. Mamm., vol. 20, pp. 376–379, 1939). Among

this group some were scarcely distinguishable from the "white-bellied agouti" strain of laboratory-bred *Mus musculus* maintained by the Jackson Memorial Laboratory. The remaining 150 individuals exhibited the normal, uniform coloration; 108 of them were "typical" and 42 were somewhat lighter on the belly but still definitely gray. The occurrence of one bicolored individual to three of normal coloration is suggestive of the phenotypic ratio of a monohybrid cross.—F. C. Evans and T. I. Storer, *Division of Zoology, University of California, Davis, California.*

MATING OF MUSKRATS

On April 24, 1941, while standing on the bank of a stream, my attention was attracted to a squeal, almost bird-like in character, coming from the opposite bank. Soon a muskrat (*Ondatra zibethica*) emerged from a dense tangle of vegetation and plunged into the river, closely followed by another individual. One individual pursued the other in a series of short turns in the water, seizing the pursued's hind quarters and attempting to mount. After five or six futile attempts, the pursuer was successful and copulation took place, the female remaining quiet from the beginning of the successful attempt in contrast to the slow turning movements carried on previously. Until copulation began, the squealing continued, coming, as far as I could determine, only from the male. Then it ceased and with the end of coition, the male turned and, swimming rapidly upstream for 15 feet, disappeared in a hole in the bank. After remaining quiet in the same position for one minute, the female swam downstream for an equal distance and also disappeared in a hole in the bank. The whole action consumed not more than five minutes and took place in about two feet of water. The observer was 50 feet distant, looking through six power binoculars. The muskrats seemed oblivious of the observer's presence.

Once before, a similar mating was seen, but, owing to greater distance and more alertness on the part of the mammals, we were not sure of all the details. At that time, the pursuit was longer and copulation apparently occurred several times. The water was barely deep enough for swimming and the date was five days earlier.—Wendell P. Smith, *Wells River, Vermont.*

A RED-GREY FOX HYBRID

Mr. Will Baker, an expert fur-buyer and handler in southeastern Ohio for the past 55 years, reports the following incident to me.

Approximately 10 years ago (1933) the pelt from an apparent red-grey fox hybrid trapped in Athens County was purchased by a local fur company in Athens, Ohio. It was a number 2 pelt in size (about the same size as an adult grey fox) and due to the combined qualities of color, character, and texture of both species, it was considered almost worthless by the fur trade.

The description of this aberrant specimen is based upon notes made by Mr. Baker at the time the fox was caught. This fox had black ears, feet, and stockings, a typical red fox (*Vulpes fulva*) face and tail, including the white tip. The back, sides, and belly were typical of the normal grey fox (*Urocyon cinereoargenteus*), but the hair was thin and of a poor grade, being similar to the general color and texture of groundhog hair. The sex of this animal is not known. Of the many thousand fox hides handled by Mr. Baker in his long career as a fur dealer, this is the only pelt of this type he has examined.

There has long been much controversy and dispute in many sportsmen and outdoor circles over the possibility of natural crossing between the red and grey fox, since many parts of the general range, local habitats, and oestrus cycles overlap. The presence of only an occasional report of such a cross, and then in widely separated areas, suggests that when (and if) hybridization occurs in these genera, the offspring do not reproduce.—Hubert Bezdek, *Ohio Division of Conservation and Natural Resources, Columbus, Ohio.*

RED FOX'S METHOD OF HUNTING FIELD MICE

On July 26, 1939, we watched a red fox (*Vulpes fulva*) hunting field mice on ground recently cleared of hay. The hour was 5.30 a.m., Eastern Daylight Time, and at that sea-

son it was not fully light. The fox was trotting back and forth, with its nose held to the ground, until a burrow apparently was scented, when the animal would pause, with ears erect and body tense, for several seconds. Then a spring followed sometimes covering as much as four feet. Always a mouse was seized, carried a few feet, bitten and thrown down. If subsequent signs of life appeared, it was picked up and bitten again. The prey was carried on to the next "hunting ground" where the process was repeated. At the end of ten minutes, the fox ran away, presumably to its burrow, carrying the morning's "bag," a mouthful. We could not determine the exact number of mice included but there were at least four. As there was a litter of young foxes within less than one-half mile, we suspected that the game was destined for them.—WENDELL P. SMITH, *Wells River, Vermont.*

ATTAINMENT OF SEXUAL MATURITY IN RACCOONS

In his recent (1943: Ecological Monographs, vol. 13, pp. 203–257) excellent account of raccoon habits in Michigan, Frederick W. Stuewer doubts that males become sexually mature during their first year. Since data on this subject are admittedly meager and inconclusive, I here present proof that sometimes raccoons do reproduce as yearlings.

In August 1941, I procured from the Chicago Zoological Society two specimens of *Procyon lotor lotor* that were young of the year and from the same litter. Although normal in color this pair had at least one albinistic parent. The parent stock had supposedly come from northern Illinois or some adjacent region. The juveniles were kept together in an outdoor cage in Cook County, Illinois, through the rest of 1941 and the first months of 1942. During all this time they remained active and ate regularly. On April 24, 1942, the female gave birth to a pair of albinos that must have been offspring of the yearling male. About the first of June the parents were disposed of and the young brought into my house for a few weeks until strong enough to live in the outdoor cage by themselves.

The infants grew into attractive pets (Natural History, vol. 51, pp. 116–119, 154, 1943) and developed normally, the male's weight on August 17 being 7 lbs. 2 oz., the female's, 6 lbs. 2 oz. They remained active through the severe winter of 1942–1943, and on February 14 weighed 16 lbs. 1 oz. and 12 lbs. 10.5 oz., the male now being much the heavier. For weeks during the late winter he constantly attempted to copulate. In April, the female's temper grew steadily worse and on the night of the 27th day of that month she gave birth to 3 or 4 young that seemed to be normal. They were not closely examined because the mother fought viciously whenever anyone approached the nest-box and I was loathe to arouse her unnecessarily.—CLIFFORD H. POPE, *Field Museum of Natural History, Chicago, Illinois.*

OS CLITORIDIS FROM THE RACOON

While skinning a large female racoon (*Procyon lotor*) taken June 11, 1942, 14 miles southwest of Meade, Meade County, Kansas, by Harry Smith of the Meade County State Park, I discovered a well developed bone in the clitoris. Subsequent dissection of three other females from the same locality revealed the presence of the bone in all specimens, in different degrees of development.

Two of the specimens were adults while the others were probably less than a year old. That the presence of the *os clitoridis* in the racoon is not an age characteristic is demonstrated by the fact that the best developed bone was found in the youngest of the adult specimens. Four other females from a distant locality, two of them old adults, were dissected and no evidence of bone or centers of ossification were found in the clitoris.

The largest and best developed *os clitoridis* of the four is 18.8 mm in length and 4.4 mm in width at the broadest (posterior) end, tapering forward to a width of 1.0 mm at a point 5.0 mm from the anterior end and then expanding again to a width of 1.7 mm (fig. 1, nos. 1 and 2).

The next largest bone, taken from the largest and oldest female, is 16.35 mm long and 4.0 mm wide at the posterior end. It tapers directly to a width of 0.9 mm at the anterior end. It is similar in shape to the one described above, except that it lacks the expanded anterior end (fig. 1, nos. 3 and 4).

When in place in the animal, this bone lies within the connective tissue sheath of the corpora cavernosa of the clitoris. It can be made to protrude from the vaginal orifice a distance of approximately one-fourth inch. It is possible that it is extruded in this manner by the erection of the clitoris during copulation.

Due to the fact that the four bones recovered are in various stages of development, some discussion of the process of ossification may be presented. It appears that the two posterior "knobs" ossify first as separate centers and later fuse. Then the ossification proceeds anteriorly and the bone reaches its full development with the formation of the expanded anterior end.

In a recent note on *os clitoridis* from *Aplodontia*, Victor B. Scheffer (Jour. Mamm., vol. 23, no. 4, p. 443) states that as far as he could discover this bone occurs only in *Aplodontia*, *Cryptomys* and *Lutra*. To this may be added *Hystrix*, since Weber figures the *os clitoridis* of *Hystrix cristata* in "Die Saugetiere," 1927, p. 351, fig. 268.

I wish to express my appreciation to Leonard Sutherland and Harry Smith of the Meade County State Game Farm for the specimens they collected in Meade County and kindly donated for this study, and to C. W. Ogle of Lawrence, Kansas, for carcasses he generously saved for dissection.—GEORGE C. RINKER, *Kansas University, Museum of Modern Vertebrates, Lawrence, Kansas.*

FIG. 1. Os clitoridis of the racoon. (1) Dorsal view, posterior end to right, (2) lateral view of same, (3) ventral view from another specimen, posterior end to right, (4) lateral view of same. ×2. Drawn by Frances Horseman.

ADDITIONAL RECORDS OF THE MERRIAM SHREW IN MONTANA

In 1942, two specimens of *Sorex merriami* Dobson were collected in Montana by a field party from the Museum of Zoology, University of Michigan. These specimens add two records of occurrence to those listed recently by Benson and Bond in their brief review of the distribution of the species (Jour. Mamm., vol. 20, pp. 348–351, 1939). They also apparently are the only specimens preserved as skins with complete, unbroken skulls from near the type locality of *Sorex merriami merriami*. Specimen number 87321 (Univ. Mich. Mus. Zool.) is from the northern flank of Cayuse Hills, about eleven miles east-northeast of Melville, Sweet Grass County, Montana. It was trapped in a *Microtus* runway in a fence row of tall grass and sweet clover (*Medicago* sp.) that separated a field of tall, dense sweet clover from an adjoining hillside sparsely covered with grass and sage (*Artemisia* sp.). Douglas fir (*Pseudotsuga taxifolia*) and juniper (*Juniperus* sp.) are the most abundant trees on the northern flanks of Cayuse Hills. Number 87338 was collected near Eagle Creek on the Madison Ranch about six miles north-northwest of Warrick in the Bearpaw Mountains of northern Montana. This locality is in extreme southeastern Hill County between the southern boundary of the Rocky Boy Indian Reservation and the Chouteau County Line. The specimen was trapped in a *Microtus* runway in a field of timothy (*Phleum* sp.) adjoining Eagle Creek. The timothy attained a height of about four feet and was closely spaced. Forests of yellow pine (*Pinus ponderosa*), Douglas fir, and aspen (*Populus tremuloides*) bordered the cultivated fields on the ranch.

Measurements (in millimeters) of numbers 87321 and 87338, respectively, follow: Total length, 98, 96; tail length, 33, 37; hind foot, 12, 12; length of head and body, 65, 59; condylobasal length of skull, 15.7, 15.7; palatal length, 6.5, 6.7; cranial breadth, 7.9, 8.5; least interorbital breadth, 3.3, 3.7; maxillary breadth, 5.0, 5.3; maxillary tooth row, 5.6, 5.6.—EMMET T. HOOPER, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

REVIEWS

Cahalane, Victor H.—Meeting the Mammals. The Macmillan Company, lx + 133, illus. Price $1.75.

Meeting the Mammals is intended for the novice visiting the National Parks and monuments of the United States west of the Mississippi River. Its pleasing style, interesting and readable contents, and animated illustrations, largely from the pen of Walter Weber, should make it a popular guide to the conspicuous and common mammals of the West.

For the professional mammalogist, this book has no value. None of the 66 mammals treated is identified beyond species and in some instances generic groups only are treated. No new information is presented. The book fulfills a definite need in the non-professional field, however, and should stimulate considerable interest in mammals among those thousands who visit the National Parks.—*W. B. Davis.*

Kenneth, J. H.—Gestation Periods—A Table and Bibliography. Imperial Bureau Animal Breeding and Genetics. Edinburgh, 9, Scotland. 23 pp. Price. 2s.

Animal breeders and those interested in life-history studies of mammals in general will find this publication highly useful. Domestic as well as wild mammals are included. The compilation includes only 48 North American land mammals, which indicates in some measure the paucity of such information on our native mammals.—*W. B. Davis.*

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COMMENT AND NEWS

To The Editor:

Sometime ago I read with great pleasure and profit "Palmar and Plantar Dermatoglyphics in Primates" by Midlo and Cummins. When reading the review of this monograph in the November issue of the Journal of Mammalogy, I began to wonder whether my memories of this excellent contribution were all wrong or whether the reviewer had not appreciated a work which is obviously beyond his field of special interest.

The reviewer states that he can "detect no important conclusions". One can only conclude that he was not interested either in the primates or in dermatoglyphics. The purpose of this study was to increase understanding of the relationships of the primates and of the morphological principles of dermatoglyphics. The monograph in question does both and the authors deserve congratulations for having succeeded in an extremely difficult task, rather than recriminations for not producing mysterious "important conclusions". Specifically, Midlo and Cummins have gathered a wealth of new data, developed methods for analyzing them, examined the classification of the primates by these methods, and discussed possible theories to account for their observations. The results are listed in a nine paragraph summary, although the reviewer states that "A categorical list of conclusions and an index would have been useful additions", leaving one with the feeling that no such summary was included. There is a very detailed table of contents which, in such a short book, makes an index a luxury.

Midlo and Cummins give a clear, brief description of their descriptive methods and of the techniques used to analyze them. The reviewer dismisses all this by saying, "This is reminiscent of much of the work done by physical anthropologists, and while I admit that I may fail to understand the object of this kind of research, most of it impresses me as a rather aimless manipulation of facts and figures—doing all the interesting things that can be done with endless series of measurements or indices, without pausing to question why." The very heart of the monograph is dismissed by saying that it is reminiscent of work which the reviewer admits that he does not understand! There is no "aimless manipulation" in *this* monograph for we are told precisely what the authors are doing and why at each stage of the analysis.

The reviewer feels that too little attention was paid to function and then only from a "negative standpoint". The question of the relation of dermatoglyphics to function is raised in the introduction, is repeatedly mentioned in the text, and is in the summary. The relation is discussed relative to habit, handedness, the functional axis, length of digits, and asymmetries of the limbs. Both normal and abnormal development are discussed to give a background. The authors examined the most recent literature on behavior (Nissen, Bingham, Carpenter). To quote from page 187, ". . . and the existence of like directions of specialization within different groups suggests that parallel or convergent evolution in dermatoglyphic features (influenced by similar functional adaptations of the members) is an actual phenomenon." Can this be called "negative" simply because it is cautious and because the authors realize the limitations of the descriptions of behavior which were available to them?

The quotation on the relation of man to the great apes is misleading because it leads one to believe that Midlo and Cummins never came to any conclusions whereas they state, ". . . it is concluded that man stemmed from an ancestral stock more primitive than any recent ape, having dermatoglyphic traits more closely allied to those of monkeys."

My conviction is that this monograph will be of interest to anyone wishing to know about dermatoglyphics. It is essential reading for anyone really concerned with the primates or human evolution.—S. L. Washburn, *Department of Anatomy, Columbia University College of Physicians and Surgeons, New York.*

ACTUAL DATES OF PUBLICATION

Actual dates of publication of volume 24 of this Journal were as follows: No. 1, February 20; No. 2, June 7; No. 3, August 18; No. 4, November 20.

OBITUARY NOTICES

CECIL F. UNDERWOOD

1867–1943

Mr. Cecil F. Underwood, veteran collector of birds and mammals of Central America, passed away on the 19th of August, 1943 after a short illness. He was born in London, England, October 26, 1867, and came to New York October 26, 1887. In April 1889, he sailed for Costa Rica on a mission to collect specimens for the American Museum of Natural History. Since that time, he has collected material for practically every museum in North and South America and Europe.

Mr. Underwood held a position in the National Museum of Costa Rica for a number of years. He exhibited a group of Tapir at the Central American Exposition of Guatemala in 1896 for which he received the Gold Medal of the Exposition. In recent years Mr. Underwood secured for the American Museum an invaluable collection of several thousand mammals from Honduras and Costa Rica, and during the early part of this year he made an extensive collection of mammals at Cañas Gordas, near the border of Panama.—George G. Goodwin.

PHILIP NELSON MOULTHROP

1911–1943

The career of one of America's most promising younger naturalists came to an end on August 21, 1943, at the Cleveland Clinic Hospital where Philip Nelson Moulthrop was suffering from influenzal meningitis. Coming as a bolt out of the blue, and when Mr. Moulthrop was but 31 years of age, the tragedy was all the more incomprehensible to those whose rare privilege it had been to work with him.

Philip N. Moulthrop was born on November 18, 1911, at Erie, Pennsylvania, the eldest of three sons of Mr. and Mrs. Ray Moulthrop. Much of his childhood was spent on his grandparents' farm near Elba, Genesee County, New York, and it was there that the boy Philip learned to know and love the out-of-doors. When he was five years of age his parents removed to Cleveland. There he attended Fairfax Junior High School and Cleveland Heights High School.

As a high school boy his interest in the out-of-doors, particularly mammals, was greatly stimulated by a part-time job he obtained at the Cleveland Museum of Natural History in the fall of 1927. Here he worked under Mr. Arthur B. Fuller in the Preparation Department. He continued as a part-time member of the staff until his matriculation in 1930 at Syracuse University, which he attended for two years.

By that time the country was deep in depression, so Philip found it necessary to leave college and go to work. For a short time he served as a filling station attendant, but returned in June, 1932, to the Cleveland Museum of Natural History as a part-time assistant. In October of that year the part-time job became a full-time one, as an assistant in the Department of Mammals. From that moment until two days before his death Philip N. Moulthrop served the Museum in several different capacities, and in every one admirably.

As a mammalogist, he will be remembered for the descriptions of mice from Anticosti Island, from Cuba, and from Ohio. As an ornithologist, he will be remembered by thousands of Cleveland citizens as one of the best-loved leaders of the Museum's bird walk program, one of the ranking local experts in field identification.

For years he had been the spark that kept alive the hope for an Aquarium for Cleveland, an interest that began to bear fruit in the summer of his death.

To a much smaller Museum-affiliated group, the Three-Corner-Round Society, Moulthrop's loss is a crushing blow, for he had risen since 1934 from linesman to chief of that natural history organization. Most of that outfit's wartime plans were carried in Mr. Moulthrop's head, as he had just returned from an expedition into the Inyo Mountains of California where he may have contracted the disease that caused his death.

Mr. Moulthrop left uncompleted penetrating studies of the seasonal pelage variation of several small mammal groups, notably *Peromyscus* as well as a revision of the *Peromyscus* of the northwestern United States and western Canada. Much of this work will be published posthumously after the war, if conditions permit.

Moulthrop is survived by his wife, Katherine Culhane Moulthrop, whom he married on December 1, 1934, and his small son, Daniel Matthew, eight years of age. There will long remain the memory of his outstanding services as an employee of the Cleveland Museum of Natural History and as a citizen of Cleveland and the nation, which he served as volunteer defense worker and as air-raid warden prior to his death.—B. P. Bole, Jr.

ANNUAL MEETING

Again this year it seems unwise to attempt a regular annual meeting of the American Society of Mammalogists. Yet it is essential that the directors vote funds for the Journal and other necessary activities during the coming year. The President also insists that an election of officers be held at least every other year. No program for the presentation of papers will be attempted as members will not be attracted from a distance, and the meeting must be held where many members reside to assure a quorum of 20.

Accordingly, a meeting of the directors will be held at the American Museum of Natural History, New York City, at 10 a.m., Friday, March 31, 1944. This will be followed, at 2 p.m., by a business meeting of the membership at large. It is urged that all local members attend.